Saskatchewan Environment

Water Pollution
Control Branch

Water Quality Study North Saskatchewan River Prince Albert Area (Autumn 1983)

September 1984
WPC 40

WATER QUALITY STUDY
NORTH SASKATCHEWAN RIVER
PRINCE ALBERT AREA
(AUTUMN 1983)

September, 1984

Water Pollution Control Branch

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ABBREVIATIONS

BOD	Biochemical oxygen demand (5-day)
DOC	Dissolved organic carbon
°C	Degrees centigrade
FC	Fecal coliforms
FS	Fecal streptococci
h	Hour(s)
Kg/d	Kilograms per day
Km	Kilometres
LB	Left bank (north shore)
MF	Membrane filtration
m^3	Cubic metres
m^3/sec	Cubic metres per second
mg/L	Milligrams per litre
ml	Millilitres
MPN	Most probable number
PCP	Pentachlorophenol
PAPCO	Prince Albert Pulp Company
RB	Right bank (south shore)
STP	Sewage treatment plant
TC	Total coliforms
TKN	Total Kjeldahl nitrogen
TSS	Total suspended solids

SUMMARY

Two intensive water quality monitoring surveys were carried out in the mid-autumn of 1983 on the North Saskatchewan River between Prince Albert and the confluence with the South Saskatchewan River. The primary objective of this investigation was to assess the impact of effluent sources on river water quality in the Prince Albert region. These impacts were assessed in relation to the provicial surface water quality objectives and identified water users. Point sources examined during this study included the City's primary sewage effluent, the Prince Albert Pulp Company effluent and the City's storm sewer discharges. A review of historical data pertaining to provincial water quality monitoring stations in the river reach under study and to municipal sewage and pulp mill effluent characteristics was also undertaken to provide background information of particular relevance to water quality characteristics of the river during past autumn periods.

The review of historical water quality data (Appendix 2) provided indication of water quality deterioration occurring in the river reach below the City of Prince Albert with respect to indicator bacteria variables. An earlier intensive study of the river in 1976 by Bell et al (1978) reported similar bacteriological impairment of the river with respect to indicator and pathogenic bacteria (salmonellae). The occurrence of oxygen depletion in the river, particularly in the lower reaches towards the confluence, was also identified from the review of

historical data. The water quality concerns related to these variables were of primary importance in the design of the autumn 1983 surveys.

Within the 66 km river reach examined in these 1983 surveys, the following water uses were identified:

- Municipal water supply (City of Prince Albert).
- Industrial supply (Prince Albert Pulp Mill).
- Irrigation (horticultural, root crops, cereal and forage).
- Reception of storm waters and municipal and industrial effluents.
- Noncontact recreation.
- Indigenous aquatic biota and wildlife.

In the present study, sampling of the river was conducted during two field surveys carried out in mid and late October 1983. Samples were collected from storm sewer outfalls along the south shore of the river within Prince Albert, while more intensive sampling was conducted on the municipal sewage effluent, the Prince Albert Pulp Mill effluent and at sites designated along the river transects (Figures 2,3). Sampling of these sites was coordinated to provide an estimate of the mixing characteristics of the major effluents in the river as well as to provide suitable information with respect to changes in water quality along and across the river as the water moved in a downstream direction.

The samples of river water and effluents were analysed for general chemical and indicator bacteriological variables (Table 2.3). Heavy metal and trace substance analyses were conducted on effluent samples, and on river water samples from selected sites.

The results of the autumn 1983 surveys indicated the following:

1. Water quality upstream of the City of Prince Albert, including that at the intake for the municipal water supply, was suitable for all use purposes addressed in the existing provincial surface water quality objectives for indicator bacteria, nutrients, general chemical, heavy metal and trace substance variables.

2. The quality of water discharged from several storm sewers within Prince Albert was found to be very poor. High levels of fecal indicator bacteria and nutrients characterized several storm sewer discharges. Entry of domestic sewage and industrial wastewater to several storm sewers was evident. Pentachlorophenol was detected in the storm sewer at 8th Avenue East.

3. In most respects, the effluents discharged by the City of Prince Albert and by the Prince Albert Pulp Company during the fall surveys were similar in quality and composition to the respective sewage and pulp mill effluents discharged in the past.

4. The municipal sewage discharge by the City of Prince Albert had a measurable impact on indicator bacteria levels in the North Saskatchewan River. The sewage effluent caused a

deterioration in the bacteriological quality of the river at all downstream locations within the plume. The plume appeared to remain relatively close to the southern shore of the river between the outfall and the first transect sampling sites (Transect R6) located 2 kilometres downstream. At 8 kilometres downstream of the outfall the plume had laterally dispersed over at least the southern three-quarters of the river width. Use of the river water in this reach is limited to seasonal irrigation of forage and cereal crops, and to non-contact recreation. Within this reach the fecal coliform levels within the effluent plume exceeded the provincial surface water quality objective for non-contact recreation. In the immediate vicinity of the pulp mill water intake, however, the bacteriological water quality was suitable for use of the water for potable supply.

At 11 kilometres below the sewage outfall the edge of the sewage effluent plume appeared to disperse to the north shore of the river. The impacts of the sewage and pulp mill effluents on water quality and use potential of the river, in terms of bacteriological surface water quality objectives, have been summarized pictorally in Figure 9 (page xii).

5. High levels of total coliform and fecal coliform bacteria were observed in the pulp mill effluent during the autumn surveys. Fecal streptococci, however, were at insignificant

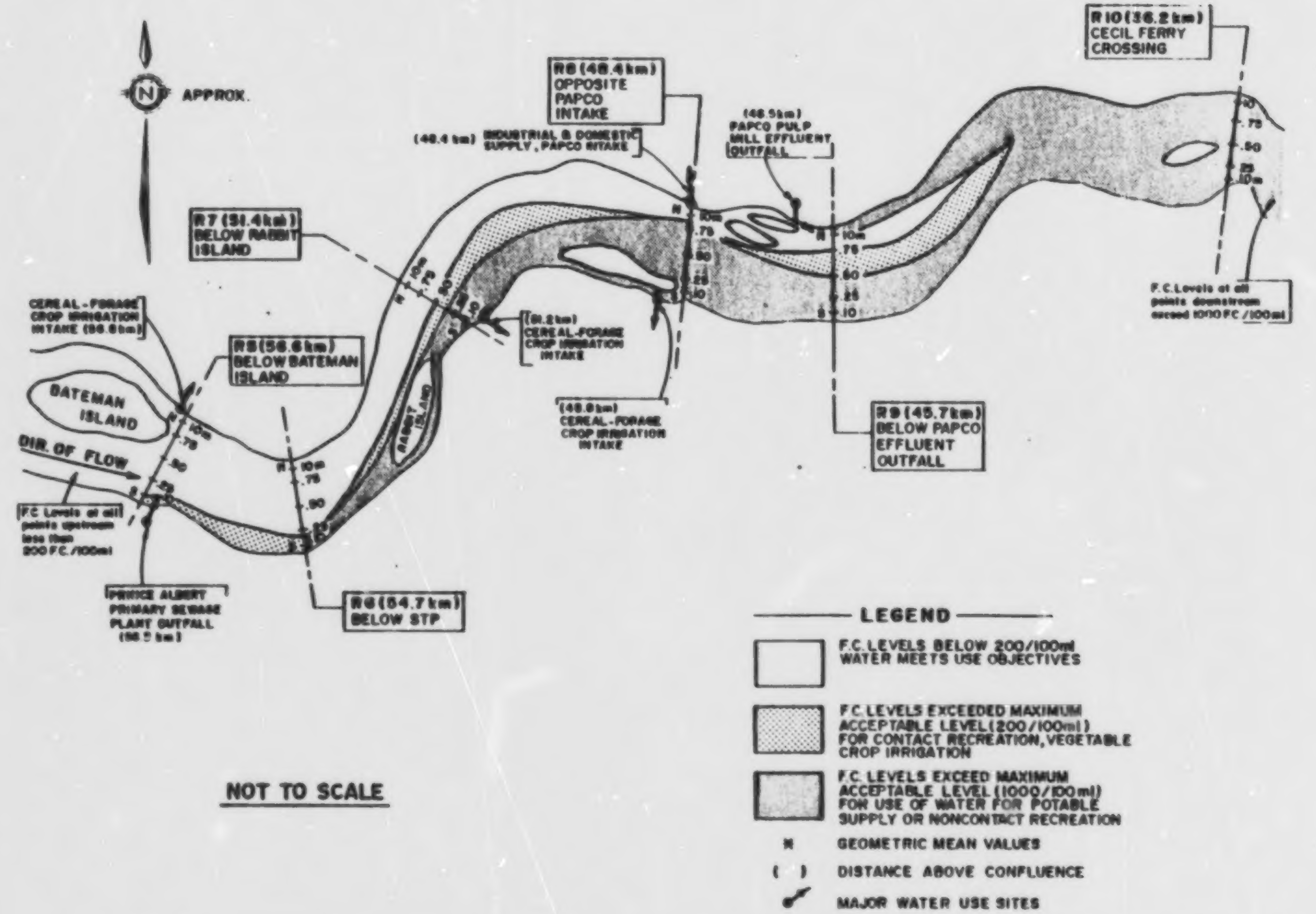

APPROX.
N
R10 (36.2 km) CECIL FERRY CROSSING
R8 (48.4 km) OPPOSITE PAPCO INTAKE
(48.4 km) INDUSTRIAL & DOMESTIC SUPPLY, PAPCO INTAKE
(46.5 km) PAPCO PULP MILL EFFLUENT OUTFALL
R7 (51.4 km) BELOW RABBIT ISLAND
CEREAL-FORAGE CROP IRRIGATION INTAKE (56.6 km)
R5 (56.6 km) BELOW BATEMAN ISLAND
BATEMAN ISLAND
DIR. OF FLOW
F.C. Levels at all points upstream less than 200 F.C./100ml
PRINCE ALBERT PRIMARY SEWAGE PLANT OUTFALL (56.5 km)
R6 (54.7 km) BELOW STP
RABBIT ISLAND
(51.2 km) CEREAL-FORAGE CROP IRRIGATION INTAKE
(48.0 km) CEREAL-FORAGE CROP IRRIGATION INTAKE
R9 (45.7 km) BELOW PAPCO EFFLUENT OUTFALL
F.C. Levels at all points downstream exceed 1000 FC/100ml
10m
.75
.50
.25
.10
NOT TO SCALE
LEGEND
F.C. LEVELS BELOW 200/100ml WATER MEETS USE OBJECTIVES
F.C. LEVELS EXCEEDED MAXIMUM ACCEPTABLE LEVEL (200/100ml) FOR CONTACT RECREATION, VEGETABLE CROP IRRIGATION
F.C. LEVELS EXCEED MAXIMUM ACCEPTABLE LEVEL (1000/100ml) FOR USE OF WATER FOR POTABLE SUPPLY OR NONCONTACT RECREATION
GEOMETRIC MEAN VALUES
( ) DISTANCE ABOVE CONFLUENCE
MAJOR WATER USE SITES

Figure 9 NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA (36.2-56.6 km above confluence) SUMMARY OF EFFECTS OF SEWAGE AND PULP MILL EFFLUENT PLUMES ON FECAL COLIFORM (F.C.) LEVELS AND WATER USE POTENTIAL IN AUTUMN 1983

levels, suggesting the high indicator bacteria populations in the mill effluent to be due to growth of enteric species in the aeration pond rather than as a direct result of fecal contamination of the mill effluent. A brief review of literature concerning bacteriological characteristics of pulp mill effluents indicated that high total and fecal coliform levels in pulp mill effluents is often associated with growth of enteric species of bacteria in the wastewater treatment systems.

6. The discharge of the pulp mill effluent to the north side of the river also had a marked influence on the bacteriological quality of the river water from transect R9 to the confluence (Figure 9).

   This effluent caused substantial increases in the levels of total and fecal coliform bacteria along the north shore of the river and added to the already elevated indicator bacteria levels which were associated with the sewage effluent plume. The combination of the two major effluents near transect R9 resulted in levels of indicator bacteria in the entire river which exceeded the existing bacteriological surface water quality objectives for non-contact recreation. The observed impacts of the pulp mill effluent on the water quality and use potential of the river have been summarized pictorially in Figure 9.

7. On the basis of bacteriological and colour analyses, and visual observations of the river water, the pulp mill effluent plume had appeared to have dispersed across the north half of the river upon reaching the Cecil Ferry crossing (R10, 10 km below the outfall). At 20 km below the outfall the entire river was brown coloured indicating lateral dispersal of the pulp mill effluent.

8. There was no apparent detrimental impact of either the sewage or pulp mill effluents on the quality of the river water with respect to general chemical variables and trace substances during the autumn 1983 surveys.

   Slight impacts with regard to loadings of some variables occurred only within the areas immediately downstream of the effluent outfalls. Significant increases in the apparent colour of the river were noted within the pulp mill effluent plume on the north side of the river between R9 and R11. In general, the water quality of the river upstream of these major effluent discharges appeared to have more influence in determining downstream water quality with respect to these variables than did the effluents.

RECOMMENDATIONS

1. Prince Albert Storm Sewers

It is evident that some of the monitored storm sewer effluents contain industrial and/or sanitary wastewaters. The City of Prince Albert should undertake the necessary investigations and corrective measures to avoid these discharges into the storm sewage works. The 6th Avenue West sewer should receive priority attention. The presence of pentachlorophenol in the 8th Avenue East storm sewer effluent is of concern. The source of pentachlorophenol was likely a former wood preserving operation located on land drained by this storm sewer.

The City of Prince Albert should undertake construction of drainage works to divert pentachlorophenol contaminated ground water to the municipal sanitary system or other suitable remedial measures at the earliest opportunity. In the interim the City should conduct regular inspections and maintenance of the containment structure at the mouth of the storm sewer to ensure its integrity.

2. Prince Albert Sewage Treatment

Based on available data, the major impact on the river relates to the bacteriological quality. The effluent is a major contributor of known human source bacterial contamination. The autumn data confirm the effluent will cause bacteriological levels in excess of water quality objectives. It is likely this would occur during other seasons.

Current use of the river in areas downstream of the sewage outfall relates mainly to noncontact recreation (canoeing, fishing, camping). In order to protect this use of the river it is recommended that the City implement effluent disinfection during the open water season. This will be even more important in protecting the expected recreational use of the pending Nipawin reservoir. During construction of the present primary treatment facility, a disinfection contact chamber was included on the basis of future disinfection requirements. Disinfection of the primary effluent may therefore be implemented without major alterations of the existing treatment facilities.

Due to the nature of the primary effluent, the system should be carefully designed and operated to ensure achievement of maximum disinfection. The City should develop plans for secondary sewage treatment as required by Section 6 of Saskatchewan Regulation 3/80. Secondary treatment would also facilitate disinfection of the effluent.

Under observed mixing conditions, the present municipal sewage outfall siting and effluent dispersion tends to minimize the impact at the pulp mill intake. It is recommended this dispersion not be altered.

Testing should be undertaken by the City of Prince Albert to ensure the effluent quality of the north septic tank meets the requirements of the Saskatchewan Environment sewage treatment guidelines (Saskatchewan Environment, 1975). Depending upon the results of this testing the city should consider the connection of the septic tank to the existing sanitary system.

3. Prince Albert Pulp Company Wastewater Treatment

The effluent contained relatively high densities of apparent total and fecal coliform bacteria. However, these high indicator bacteria levels may be attributable to the growth of enteric species in the wastewater system and not the direct result of the concomitant discharge of undisinfected sanitary wastes into the system. Assuming that the indicator bacteria in the pulp mill effluent are of non-fecal origin, there would not be a health concern for this aspect of the discharge at this time. Supporting evidence for this conclusion has been reported for pulp mills in Ontario but it should be confirmed for the effluent at the Prince Albert pulp mill.

It is therefore recommended that the Prince Albert Pulp Company undertake a water quality study to confirm the non-fecal origin of the indicator bacteria discharged in the pulp mill effluent. The study should include intensive monitoring for fecal streptococci, and species identifications of the dominant fecal coliform bacteria isolated from the final effluent. Further recommendations concerning the combined treatment of sanitary and industrial wastewaters or for disinfection of the sanitary wastes at the mill will be made on the basis of the results of the water quality study.

4. Compliance Monitoring

Conditions of approval of operation of municipal and industrial wastewater treatment systems in the province generally include a requirement for monitoring of effluents and/or receiving waters for indicator bacteria (total and fecal coliforms). Fecal streptococci are routinely determined during monitoring of surface waters in the province to provide supplementary information about the sanitary conditions of water bodies. It is recommended that monitoring of effluents and receiving waters for fecal streptococci be required for the City of Prince Albert and for the Prince Albert Pulp Company wastewater treatment systems.

5. Mixing Zones

As indicated by the results of the autumn 1983 study (e.g. Figure 9) knowledge of the mixing characteristics of effluents in surface water bodies can be of considerable value in assessing the potential effects of contaminants on water use at various sites along watercourses. It can also provide information about dilution and assimilation of contaminants over time and distance from the effluent outfall. It is recommended that a policy be developed to provide guidelines for establishing effluent mixing zones in surface water bodies and for the application of surface water quality objectives to these zones.

6. Further Monitoring

Following completion of remedial work considered in Recommendation 1, the storm sewer effluents should be monitored to confirm implementation of the corrective measures.

Further bacteriological monitoring of the river downstream of the City of Prince Albert should be undertaken during the first summer following initiation of sewage effluent disinfection at the municipal primary treatment plant. Also at that time diurnal monitoring of oxygen levels and of water temperature should be conducted.

Use of the water in downstream areas of the river may change with future developments in the basin. Because of the likelihood of the undisinfected sewage effluent and/or pulp mill effluent resulting in elevated levels of fecal coliform bacteria in downstream areas of the North Saskatchewan River, as well as in waters of the Saskatchewan River impounded by reservoir development, it is recommended that long term plans be developed for water quality studies to be conducted in these areas to assess the potential affects on water use. Emphasis at that time should be made on the application of new analytical procedures specific for indicator bacteria of fecal origin (e.g. *Escherichia coli*, fecal enterococci).

1. INTRODUCTION

1.1 Background

Water quality monitoring of the North Saskatchewan River has been undertaken for a number of years. Much of this work has been carried out on a routine or regular program basis and has resulted in a considerable amount of long-term data from periodic grab samples.

A more detailed water quality investigation of the North Saskatchewan River was conducted by the Water Pollution Control Branch of Saskatchewan Environment during 1981 and 1982. The results of this more intensive study (Saskatchewan Environment 1984) revealed a possible bacterial pollution problem in the Prince Albert area, as had been earlier suggested by Bell et al (1978).

In light of these results, it was decided that a more detailed survey should be conducted in the Prince Albert area in order that potential problems could be more accurately delineated and possible remedial measures identified. A study plan was prepared and the water quality investigation was undertaken in the fall of 1983. The results of this investigation form the basis for this report.

1.2 Scope and Objectives

The primary objective of this study was to obtain data suitable to assess probable pollution sources and the impact on water quality in the region of the City of Prince Albert in relation to the identified water uses and the provincial surface water quality objectives. Emphasis was placed on point source effluents located in the area from immediately upstream of Prince Albert to the confluence of the North Saskatchewan River with the South Saskatchewan River. Point sources considered during this study were the city's primary sewage effluent and the Prince Albert Pulp Company (PAPCO) effluent and the city's storm sewer discharges.

For the evaluation of the Prince Albert sewage effluent quality, the variables investigated were those which are generally associated with an urban sewage (e.g. nitrogen, phosphorus, carbon, chloride, suspended solids, biochemical oxygen demand, pH, temperature, conductivity, total alkalinity). Heavy metal and trace substances were also determined on the sewage effluent. The greatest emphasis was placed on the bacteriological quality of the river because of the high values for bacteria observed among historical data (Appendix 2) and the bacteriological concerns identified in a previous study by Bell et al (1978).

Other concerns related to low oxygen levels and to colour and resin acids concentrations which have been observed in the Prince Albert area, and some of these considerations were investigated during the survey. Sampling schedules were coordinated with estimated time of travel of the river water in order to obtain additional information about water quality changes which might occur as slugs of water moved downstream and to determine the effluent mixing characteristics in the river. As well, some samples were collected to supplement data previously obtained from the provincial primary water quality network stations. These results, when combined with historical data were intended to provide a better assessment of the water quality of the North Saskatchewan River, and a better understanding of the assimilative capacity of the watercourse.

During the survey, only samples of river water and effluents were collected for analyses. No sampling was conducted with respect to sediments or biota.

1.3 Water Uses

Within the 68.5 kilometre reach from the mouth of the Sturgeon River to the confluence of the North and South Saskatchewan Rivers, the following uses and users have been identified:

- Municipal water supply (City of Prince Albert).
- Industrial and domestic water supply (PAPCO).
- Reception of storm waters and municipal and industrial effluents.
- Non-contact recreation.
- Indigenous aquatic biota and wildlife.
- Seasonal irrigation of forage, cereal and root crops, horticultural.

A listing of known major intakes and point source effluent discharges is provided in Appendix 1.

1.4 Hydrology

Hydrologic considerations play a very important role in the study of river water quality. Flow characteristics determine the physical dynamics of the watercourse which in turn affect chemical and biological processes. Of obvious importance are such topics as flow rate, mixing patterns, and time of travel.

Historically, the natural flow regime of the North Saskatchewan River was characterized by very low winter flows, followed by two periods of much higher flows: one in April and May associated with snowmelt from prairie tributaries and one in June and July associated with mountain runoff. This seasonal pattern has been altered in the recent past by the presence of the Big Bend (1965) and Big Horn (1972) hydroelectric dams in Alberta. As a result of water storage practices in these upstream areas, winter flows have increased and spring and summer flows have decreased. However, total annual flow volumes have not changed significantly (Prairie Provinces Water Board, 1982).

Surface water flow data are available for a station on the North Saskatchewan River at Prince Albert. Information for the post-impoundment period of 1973 to 1982 is illustrated on Figure 1. Lowest flows occur during the November to March period, and

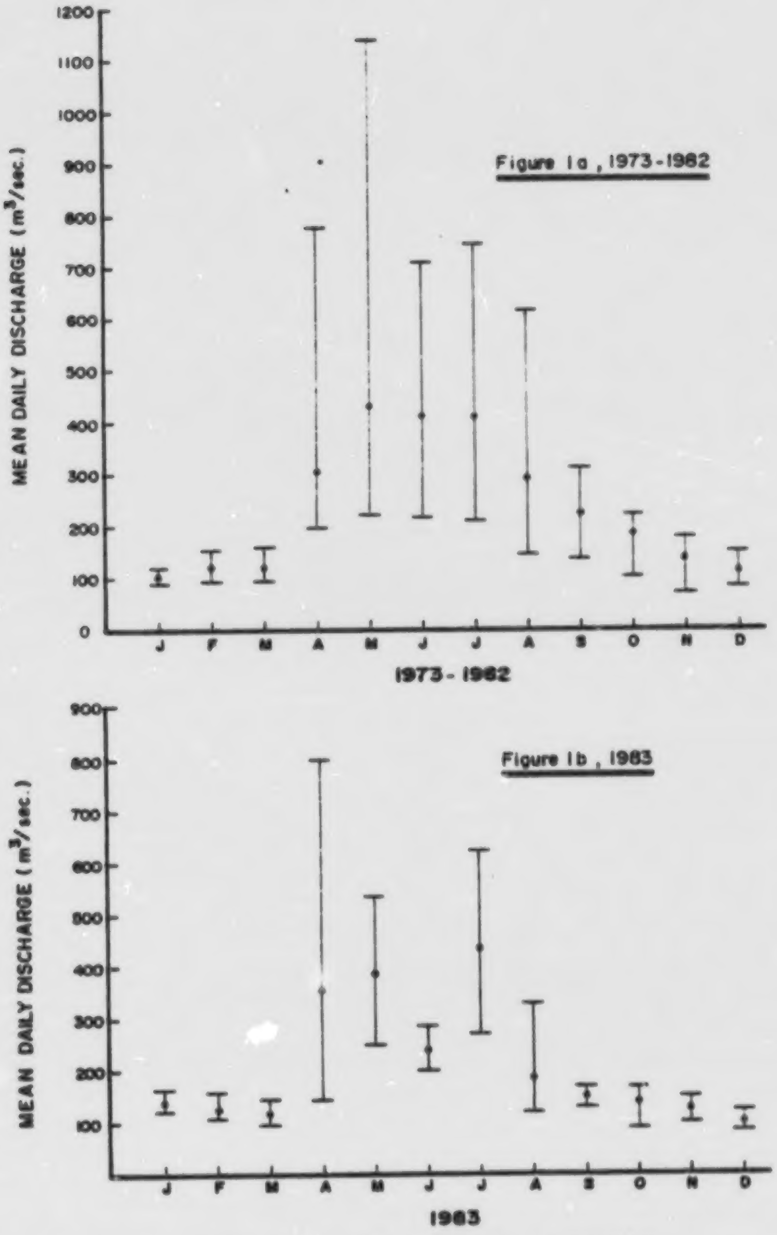


Figure 1 MONTHLY MEAN FLOWS (m^3/sec.) FOR THE NORTH SASKATCHEWAN RIVER AT PRINCE ALBERT IN 1983 AND DURING THE PERIOD 1973 - 1982 (MEAN DAILY DISCHARGE AND RANGES).

highest flows are recorded during May, June, and July. In spring the increase in flow rate is quite abrupt while during the fall the decrease is more gradual. Provisional data for 1983 (Figure 1) show a similar pattern although late spring and early summer flows in 1983 were lower than those generally recorded in the past.

For estimating time of travel, Water Survey of Canada provided the following information:

- Mean velocity at the Prince Albert station at a discharge rate of 171 m^3/sec is 0.6 m/sec.

- Time-of-travel under ice at a discharge rate of 161 m^3/sec by reaches:
  - Diefenbaker Bridge to PAPCO intake - 1.55 km/h.
  - PAPCO intake to Cecil Ferry - 1.72 km/h.
  - Cecil Ferry to Confluence - 2.19 km/h.

(Ice cover velocities may be 0.86 of open water velocities.)

Because river discharge had been estimated to be 160 m^3/sec for the survey period (Hydrology Branch), the above information was used to estimate time-of-travel for the study area. Calculated velocities used to establish sampling times are listed below:

Reach	Estimated Velocities (km/h)
To PAPCO intake	1.79 to 2.16
PAPCO intake to Cecil Ferry	2.0 to 2.41
Cecil Ferry to confluence	2.55 to 3.07

Estimated flow rates for the survey dates are provided in Table 1.1. The discharge rate of the river was somewhat lower than had been predicted at the time the study plan was formulated. However, because the study area represented a relatively short stretch of the river and because a certain amount of flexibility had been built into the program to allow for sampling time, it is felt that time-of-travel was reasonably approximated during this investigation.

The river flow rates observed during the two fall 1983 surveys were reasonably typical and were not much lower than some of the minimum summertime flows that have been recorded.

TABLE 1.1
NORTH SASKATCHEWAN RIVER AT PRINCE ALBERT
FLOWS DURING THE STUDY PERIOD

Date (1983)	Flow Rate (m^3/sec)
October 17	130
October 18	130
October 19	125
October 20	150
October 31	135
November 1	135
November 2	125
November 3	130

1 - as estimated by the Hydrology Branch, Saskatchewan Environment.

1.5 Historical Water Quality

Water quality data have been collected at six provincial monitoring locations within the lower river reach since 1970. A summary of these historical data pertaining to selected chemical and bacteriological variables is presented in Appendix 2.

The review of data concerning bacteriological indicator variables revealed geometric mean values for total coliforms (TC) and fecal coliforms (FC) at areas downstream of the City of Prince Albert and the pulp mill (e.g. Cecil Ferry, Cole Rapids, Confluence) which exceeded the current provincial surface water quality objectives for contact and noncontact recreation and vegetable crop irrigation use, as well as for use of the river for withdrawl for treatment and distribution as a potable supply (Saskatchewan Environment 1975). These observations were apparent for both the annual and seasonal (fall) geometric mean data summaries. There was a tendency, however, for considerably lower FC densities occurring towards the north side of the river at Cecil Ferry than on the south side. Also with regard to this variable, there was a tendency for higher individual values and for higher geometric mean values (annual and seasonal) derived from multiple tube fermentation (MPN) analyses than from membrane filtration (MF) analyses for each of the six monitoring stations. These MPN and MF results indicated significant sources of indicator bacteria to be entering the river at points downstream of the Prince Albert water treatment plant.

Although individual chloride levels apparently fluctuated considerably the mean values for both annual and fall periods at all stations were similar except for somewhat higher mean values for the station towards the north side of the river at Cecil Ferry. Specific conductance annual and fall mean values at all stations were similar but there was a tendency for higher values in the northern portion of the river at Cecil Ferry.

Dissolved oxygen data indicate that levels of oxygen below the provincial surface water quality objectives were observed at all stations occasionally over the past 12 years. However, mean values for annual and fall periods during this time have been above the objective. Nevertheless, very low values have been observed at each site with almost complete depletion of oxygen being noted for the confluence area where the most extreme range of oxygen values was recorded (0.09 - 20 mg/L). In general the occurrences of very low oxygen levels in the river have been limited to winter and spring periods in the past and have not been observed during the autumn season.

Similar observations concerning the percent saturation of oxygen in water can be made from the data related to these stations as well. In these data there is an apparent tendency towards lower minimum percent saturation values towards the downstream stations. Supersaturated conditions were observed for both the annual and fall data at all stations. Annual and fall mean values for this variable range from 76.8 - 84.4 percent and 90.7 7 102.1 percent, respectively.

Biochemical oxygen demand data do not reveal great fluctuations in the loading of oxygen consuming materials at these six stations. In terms of annual and fall mean values, there is relatively little difference between the stations although slightly higher mean values can be noted for the northern portion of the river at Cecil Ferry. A similar observation for total organic carbon may also be made for these stations.

The historical data concerning annual and fall mean values of total suspended solids, total Kjeldahl nitrogen, and total phosphorus were similar at these monitoring stations. The fall mean values for each variable tended to be lower at each station than those pertaining to annual data.

For the foregoing variables, historical data indicate little apparent impact from known effluent discharges to the river in the Prince Albert area except for the bacteriological indicators and oxygen deficiencies in downstream areas.

2. MONITORING PROGRAM

2.1 Sampling Locations

The study area encompassed the lower 66 km reach of the North Saskatchewan river, extending from upstream of the City of Prince Albert to the confluence of the North and South Saskatchewan Rivers.

In preparation for sampling surveys, 13 sampling transects were established along this river reach in early October 1983. Coloured wooden stakes were used to mark the ends of most transects. This was done to assist samplers in locating sampling stations along the transects where no fixed landmarks such as bridges were present. The location of each sampling transect, as well as major effluent discharge points, are shown on Figure 2. The locations of other point source discharges (eg: storm sewer outfalls) are shown on Figure 3.

Along all transects, except R2 and R13, two or more locations were designated for sampling. These stations were located at specific distances along the transects from either the right (south) or left (north) bank of the river. The right and left bank designation corresponds, respectively, to the south and north shores of the river when viewed in a downstream, easterly direction. The position of sampling locations along each transect is shown in Table 2.2.

Although 28 drainage channels and storm sewers were identified as possible sources of pollutants to the river (Appendix 1), sampling was restricted to those which were sampled in earlier surveys or which were observed to be discharging potentially significant amounts of polluting materials during each field survey. These stormwater outfalls are listed in Table 2.2.

TABLE 2.1
NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
RIVER SAMPLING LOCATIONS AND FREQUENCIES, FALL 1983

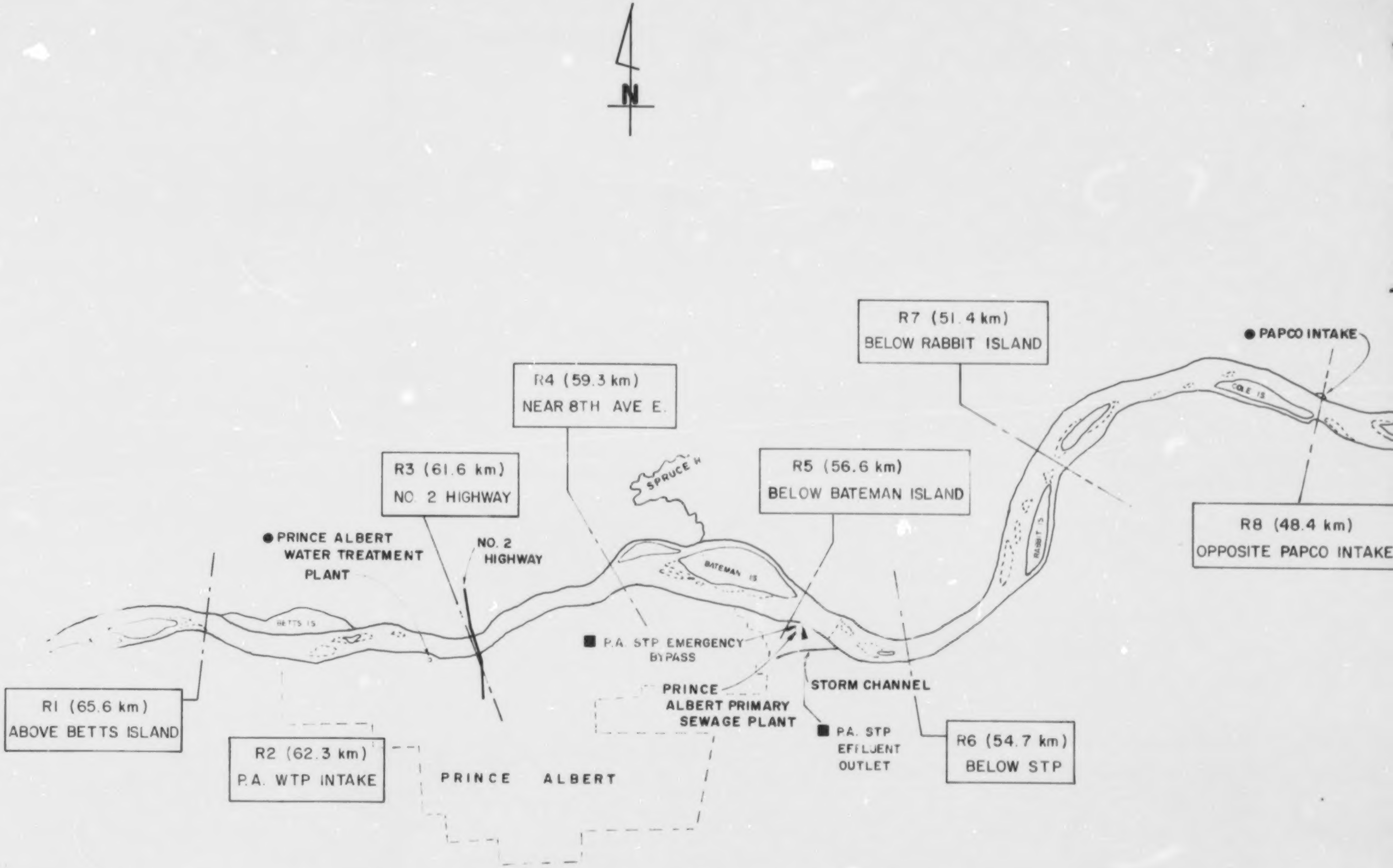
Transect Number	Map Description	Distance Upstream From Confluence (km)	Sampling Location[1]	Sampling Frequency First Survey (October 17-20)	Sampling Frequency Second Survey (Oct 31-Nov 3)
R1	Above Betts Island	65.6	.25 RB	Day 1	Day 1
			.50 RB	Day 1	Day 1
			.75 RB	Day 1	Day 1
R2	P.A. WTP Intake	62.3	intake(RB)[2]	Day 1	Day 1
R3	No. 2 Highway	61.6	100 m LB	Day 1	Day 1
			10 m LB	Day 1	Day 1
R4	Near 8th Ave. E.	59.3	10 m RB	Day 1	Day 1
			.25 RB	Day 1	Day 1
			.50 RB	Day 1	Day 1
			.75 RB	Day 1	Day 1
R5	Below Bateman Island	56.6	10 m RB		Day 1,2,3
			.25 RB	Day 1,2,3	Day 1,2,3
			.50 RB	Day 1,2,3	Day 1,2,3
			.75 RB	Day 1,2,3	Day 1,2,3
R6	Below STP	54.7	10 m RB	Day 2	Day 2
			.25 RB	Day 2	Day 2
			.50 RB	Day 2	Day 2
			.75 RB	Day 2	Day 2
R7	Below Rabbit Island	51.4	10 m RB	Day 2,3	Day 2,3
			.25 RB	Day 2,3	Day 2,3
			.50 RB	Day 2,3	Day 2,3
			.75 RB	Day 2,3	Day 2,3
			10 m LB		Day 2,3

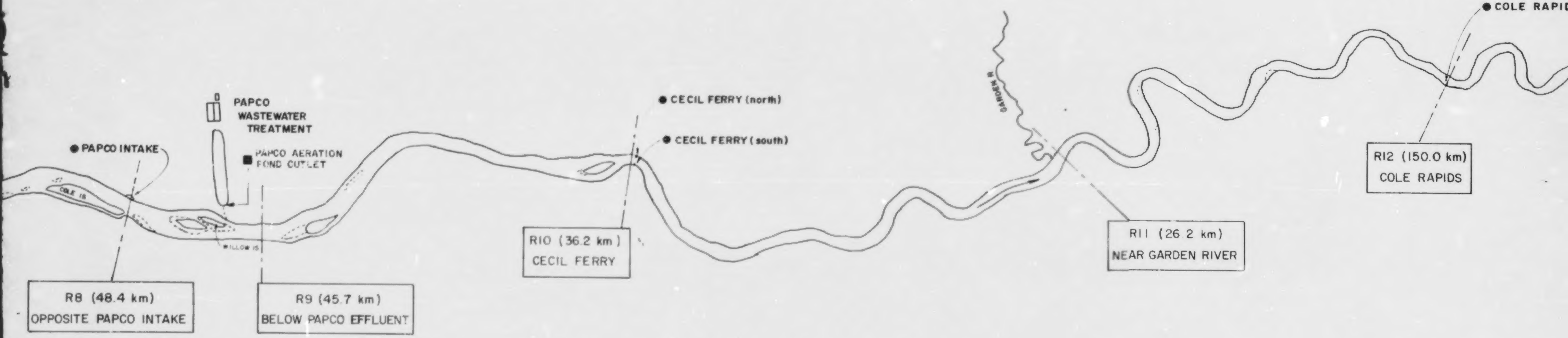
TABLE 2.1 (Cont'd)

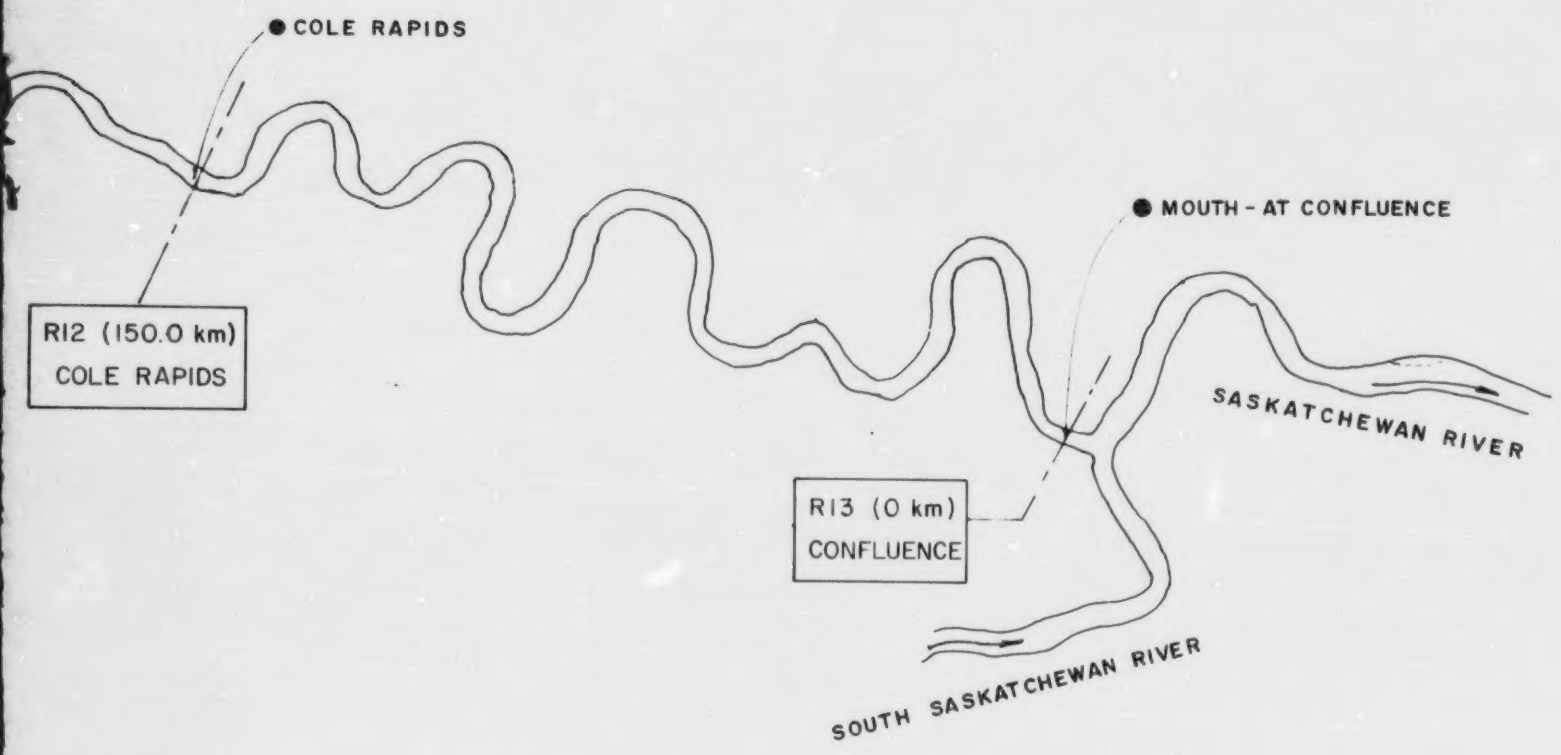
Transect Number	Map Description	Distance Upstream From Confluence (km)	Sampling Location^1	Sampling Frequency First Survey (October 17-20)	Sampling Frequency Second Survey (Oct 31-Nov 3)
R8	Opposite PAPCO Intake	48.4	10 m RB	Day 2,3,4	Day 2,3,4
			.25 RB	Day 2,4	Day 2,3,4
			.50 RB	Day 2,3,4	Day 2,3,4
			.75 RB	Day 3	Day 2,3,4
			10 m LB		Day 2,3,4
			Intake (LB)^2	Day 2,3,4	Day 2,3,4
R9	Below PAPCO Effluent	45.7	10 m RB	Day 2,3	Day 2,3
			.25 RB	Day 2,3	Day 2,3
			.50 RB	Day 2,3	Day 2,3
			.75 RB	Day 2,3	Day 2,3
			10 m LB	Day 2,3	Day 2,3
R10	Cecil Ferry	36.2	.33 RB	Day 2,3,4	Day 2,3,4
			.50 RB	Day 2,3,4	Day 2,3,4
			.33 LB^2	Day 2,3,4	Day 2,3,4
			10 m LB		
R11	Near Garden River	26.2	.25 RB	Day 3	Day 3
			.50 RB	Day 3	Day 3
			.75 RB	Day 3	Day 3
			10 m LB		Day 3
R12	Cole Rapids	15.0	RB^2	Day 2,3	Day 2,3
			.33 RB	Day 2	
			.50 RB	Day 1	
R13	Confluence	0	RB^2	Day 2	Day 2

[1] - RB = Right (South) Bank; LB = Left (North) Bank

[2] - Sampling location coincides with network monitoring station.


N
R1 (65.6 km)
ABOVE BETTS ISLAND
R2 (62.3 km)
P.A. WTP INTAKE
R3 (61.6 km)
NO. 2 HIGHWAY
R4 (59.3 km)
NEAR 8TH AVE E.
R5 (56.6 km)
BELOW BATEMAN ISLAND
R6 (54.7 km)
BELOW STP
R7 (51.4 km)
BELOW RABBIT ISLAND
R8 (48.4 km)
OPPOSITE PAPCO INTAKE
● PRINCE ALBERT WATER TREATMENT PLANT
NO. 2 HIGHWAY
BETTS IS
SPRUCE R
BATEMAN IS
RABBIT IS
COLE IS
● PAPCO INTAKE
■ P.A. STP EMERGENCY BYPASS
PRINCE ALBERT PRIMARY SEWAGE PLANT
STORM CHANNEL
■ P.A. STP EFFLUENT OUTLET
PRINCE ALBERT


PAPCO INTAKE
PAPCO
WASTEWATER
TREATMENT
PAPCO AERATION
POND OUTLET
COLE IS
WILLOW IS
CECIL FERRY (north)
CECIL FERRY (south)
GARDEN R
COLE RAPID
R8 (48.4 km)
OPPOSITE PAPCO INTAKE
R9 (45.7 km)
BELOW PAPCO EFFLUENT
R10 (36.2 km)
CECIL FERRY
R11 (26.2 km)
NEAR GARDEN RIVER
R12 (150.0 km)
COLE RAPIDS


COLE RAPIDS
MOUTH - AT CONFLUENCE
RI2 (150.0 km)
COLE RAPIDS
RI3 (0 km)
CONFLUENCE
SASKATCHEWAN RIVER
SOUTH SASKATCHEWAN RIVER

● EXISTING WATER QUALITY MONITORING NETWORK STATIONS

■ MAJOR EFFLUENT DISCHARGE SAMPLING LOCATIONS

NOTE: STATION LOCATIONS AND
DISTANCE DESIGNATIONS
ARE APPROXIMATE

SCALE 1:60 000

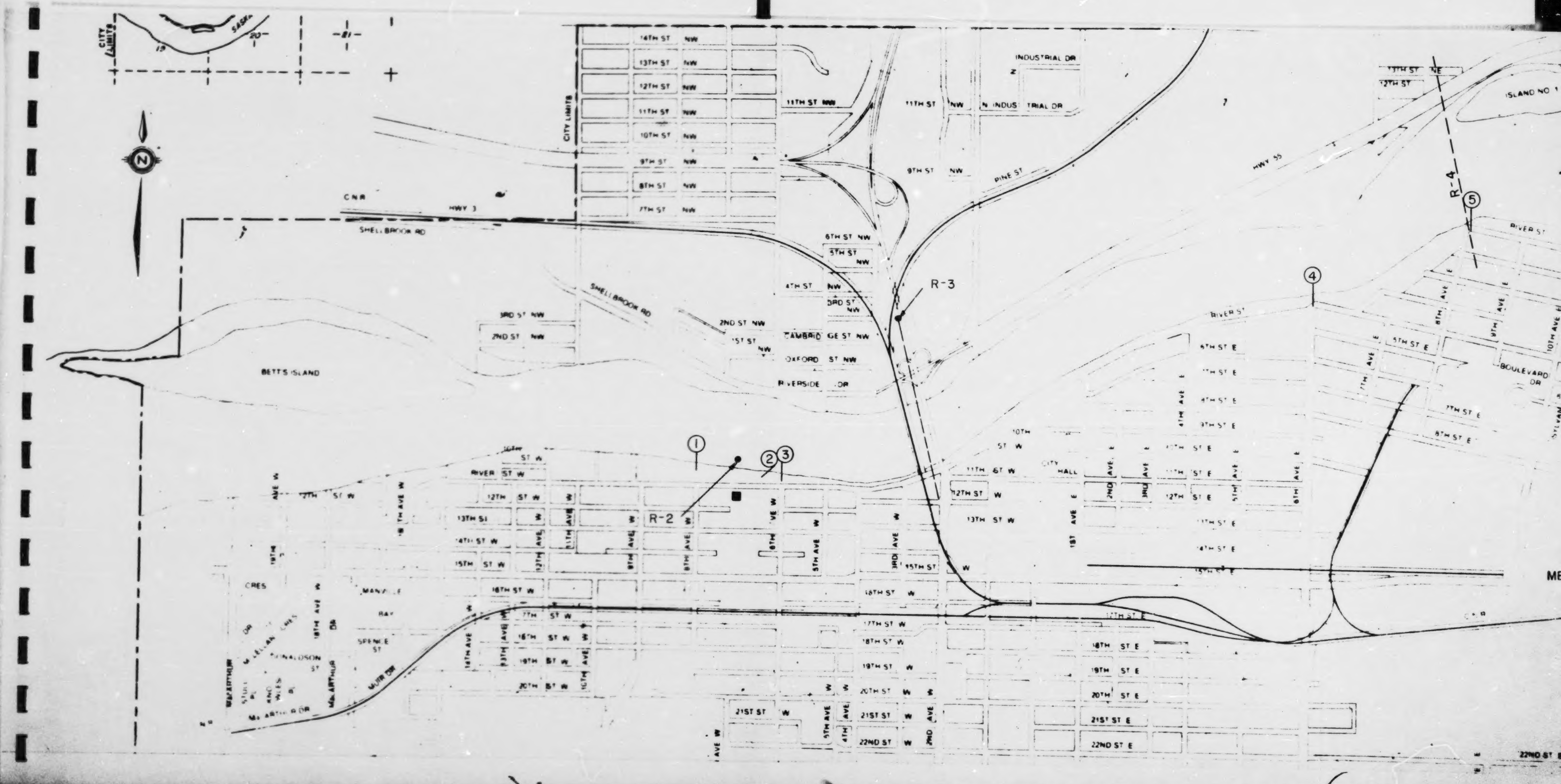
CSMA AIR PHOTOS
80004-17-49
80004-22-48

Saskatchewan Environment
Water Pollution Control Branch

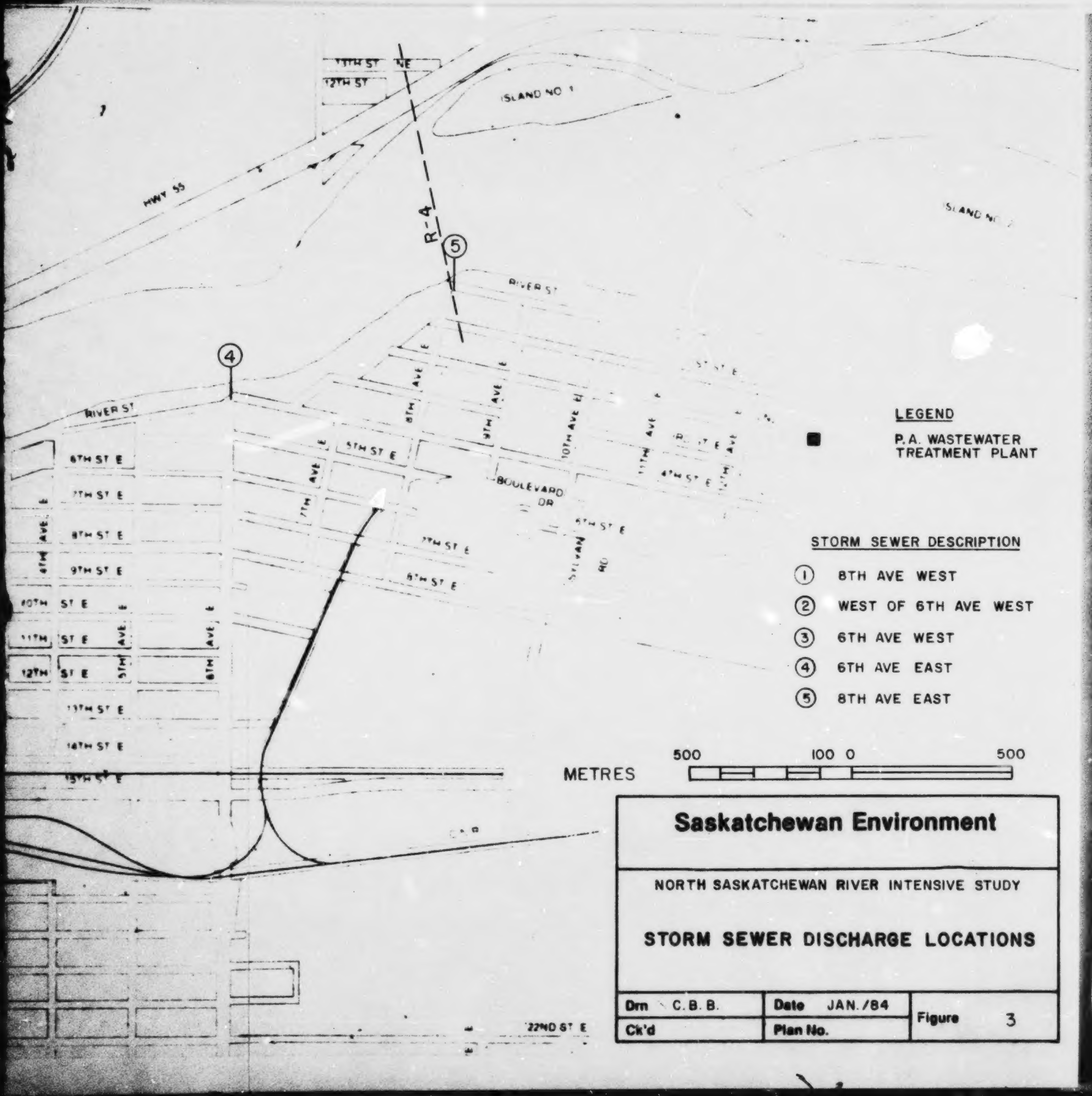
NORTH SASKATCHEWAN RIVER
PRINCE ALBERT AREA

WATER QUALITY STUDY DESIGN

Drn CBB/	**Date** JAN. 1984	**Figure** 2
Ck'd	**Plan No.**	



CITY LIMITS
SASK
19
20
21
N
CNR
HWY 3
SHELLBROOK RD
14TH ST NW
13TH ST NW
12TH ST NW
11TH ST NW
10TH ST NW
9TH ST NW
8TH ST NW
7TH ST NW
6TH ST NW
5TH ST NW
4TH ST NW
3RD ST NW
2ND ST NW
1ST ST NW
CAMBRIDGE ST NW
OXFORD ST NW
RIVERSIDE DR
INDUSTRIAL DR
N INDUSTRIAL DR
PINE ST
HWY 55
ISLAND NO 1
13TH ST NE
12TH ST
R-3
R-4
R-2
①
②
③
④
⑤
RIVER ST
BETT'S ISLAND
RIVER ST W
12TH ST W
13TH ST
14TH ST W
15TH ST W
16TH ST W
17TH ST W
18TH ST W
19TH ST W
20TH ST W
21ST ST W
22ND ST W
CRES
MANVILLE BAY
SPENCE ST
DONALDSON ST
McARTHUR DR
MUIR DR
19TH AVE W
18TH AVE W
14TH AVE
13TH AVE
12TH AVE
11TH AVE
10TH AVE
9TH AVE
8TH AVE W
6TH AVE W
5TH AVE W
4TH AVE
3RD AVE W
2ND AVE
1ST AVE E
CITY HALL
10TH ST W
11TH ST W
12TH ST W
13TH ST W
15TH ST W
6TH ST E
5TH ST E
7TH ST E
8TH ST E
9TH ST E
10TH ST E
11TH ST E
12TH ST E
13TH ST E
14TH ST E
15TH ST E
17TH ST E
18TH ST E
19TH ST E
20TH ST E
21ST ST E
22ND ST E
2ND AVE E
3RD AVE E
4TH AVE E
5TH AVE E
6TH AVE E
7TH AVE E
8TH AVE E
9TH AVE E
10TH AVE E
BOULEVARD DR
SYLVAN
CNR
ME


11TH ST NE
12TH ST
ISLAND NO 1
HWY 55
ISLAND NO 2
R-4
⑤
④
RIVER ST
RIVER ST
6TH ST E
7TH ST E
8TH ST E
9TH ST E
10TH ST E
11TH ST E
12TH ST E
13TH ST E
14TH ST E
15TH ST E
22ND ST E
4TH AVE E
5TH AVE E
6TH AVE E
7TH AVE E
8TH AVE E
9TH AVE E
10TH AVE E
11TH AVE E
12TH AVE E
5TH ST E
4TH ST E
BOULEVARD DR
5TH ST E
7TH ST E
8TH ST E
SYLVAN RD
METRES
500
100 0
500

LEGEND

■ P.A. WASTEWATER TREATMENT PLANT

STORM SEWER DESCRIPTION

① 8TH AVE WEST
② WEST OF 6TH AVE WEST
③ 6TH AVE WEST
④ 6TH AVE EAST
⑤ 8TH AVE EAST

Saskatchewan Environment

NORTH SASKATCHEWAN RIVER INTENSIVE STUDY

STORM SEWER DISCHARGE LOCATIONS

Drn C.B.B.	Date JAN./84	Figure 3
Ck'd	Plan No.	

TABLE 2.2
LIST OF STORM SEWER DISCHARGES
SAMPLED IN PRINCE ALBERT AREA
OCTOBER, NOVEMBER 1983

Storm Sewer Outfall	Location (All on right, or south, bank)
8th Avenue West	About 1000 m upstream of transect R3.
West of 6th Avenue West	About 800 m upstream of transect R3.
6th Avenue West	About 750 m upstream of transect R3.
6th Avenue East	About 2.6 km downstream of transect R3.
8th Avenue East	At transect R4.

Note: Sampling site locations are shown on Figure 3.

2.2 Sampling Intervals

Sampling surveys were conducted on two occasions. The first survey was carried out during the period October 17 - 20, 1983, and the second during the period October 31 to November 3, 1983. In all instances, except for those locations added to the study during the second survey, each sampling location was sampled at least once in both surveys. The river sampling locations and frequency of samplings at each site are shown in Table 2.1.

As noted previously, the study was designed to take time-of-travel into account. Sampling intervals were therefore established to follow four separate "slugs" of water moving through the study area during each of the 2 surveys. Transects and point source effluents investigated as the columns of water moved through the area were as follows:

Column No. 1 - Transects R1, R2, R3, R4, R12, R13.

Column No. 2 - Transects R5, STP effluent, Transects R6, R7, R8, PAPCO effluent, Transects R9, R10.

Column No. 3 - Transect R5, STP effluent, Transects R7, R8.

Column No. 4 - PAPCO effluent, Transects R9, R10, R11.

2.3 Variables

The water quality variables examined during the surveys included field tests for pH, temperature, conductance, dissolved oxygen, and physical characteristics of each sampling site. The water and effluent samples obtained from the sites at frequencies described in Table 2.1 were analysed for various chemical and bacteriological variables including nutrients, heavy metal and trace substances, colour, resin acids, sulphides, mercury, and indicator bacteria. A list of the individual variables examined at the transect stations during the study is presented in Table 2.3

All river water and effluent samples collected during the two surveys were analysed for TC, FC and FS bacteria using standard membrane filtration (MF) procedures (American Public Health Association 1980). MF procedures provide greater precision and similar recoveries of indicator bacteria compared to results obtained with most-probable-number (MPN) tube fermentation methods and are particularly useful when analysing pulp mill wastewaters and mill receiving waters (U.S.E.P.A. 1973).

TABLE 2.3
NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
WATER QUALITY VARIABLES - OCTOBER, NOVEMBER 1983

Field Observations	Applicable Samples *
Dissolved Oxygen pH Temperature Conductance Physical Description Transect Width Physical Characteristics of sampling location	All river transect and point source effluent stations on all dates.
Laboratory Analyses	
Total Kjeldahl nitrogen Nitrate/nitrite nitrogen Ammonia Total Phosphorus Dissolved Orthophosphorus Biochemical Oxygen Demand Total Suspended Solids Volatile Suspended Solids Dissolved Organic Carbon Conductivity pH Total Alkalinity Dissolved Chloride Total Coliforms Fecal Coliforms Fecal Streptococci	All river transect and point source effluent stations on all dates.
Colour	All stations and all dates for transects R8, R9, R10, R11, R12, R13; PAPCO effluent on all dates.
Resin Acids Sulphides Mercaptans	Intake station (LB) on transect R8 and RB station on transect R12 on Day 3; PAPCO effluent on all dates.
Heavy Metals and Trace Substances (Al, As, Ba, B, Cd, Ca, Cu, Cr, Co, CN^-, Fe, Pb, Mg, Mn, Hg, Mo, Ni, P, K, Se, Si, Ag, Na, Ti, V, W, Zn)	.5 RB station on transect R5 and RB station on transect R12 on second day of each survey; STP and PAPCO effluents on all dates.
Mercury	All stations on all dates for transects R5, R8, R10, and PAPCO intake and effluent, STP effluents in each survey.
Field Observations	**Applicable Samples**
Hg	All stations at R12 in survey 1 day 2;RB station only on day 3 of survey 1 and days 2 and 3 of survey 2.
Major Ions (HCO_3, CO_3, Cl, SO_4, Ca, Mg, K, Na) Phenols Biocides	RB station at transect R12 on day 2 of survey 1 only.
Pentachlorophenol	R1 at .5 RB, R4 at 10 m RB, .25 RB and .5 RB and 8th Avenue East storm sewer on day 1 of survey 2 only.

* LB - left bank
RB - right bank
PAPCO - Prince Albert Pulp Company
STP - Prince Albert Sewage treatment plant

In addition to the routine enumerative analyses of samples for indicator bacteria, analyses were also conducted to determine some of the genera and species of bacteria which were recovered from various water and effluent samples by membrane filtration as fecal coliforms (FC) or as a typical target and non-target (background) bacterial colonies. Generally the membrane filters used for providing these cultures for identification were those used to analyse small volumes of sample and which yielded countable numbers of FC colonies. A total of 41 colonies of bacteria from 18 water and sewage samples were selected for identification. The identification of these cultures was carried out by the Provincial Laboratory in Regina.

2.4 Data Acquisition/Analysis

Field measurements and the collection of water quality samples were carried out following techniques described in the Water Pollution Control Branch procedures manual (Saskatchewan Environment 1984).

Dissolved oxygen concentrations were determined by the Winkler procedure on samples collected and preserved in the field. Titrations were conducted in the field at the end of each work day. Water temperatures were determined at most sites using an alcohol filled field thermometer. Specific conductance (conductivity) and pH were determined, on the 4 L samples destined for major ion and nutrient analyses, at the end of each work day using a Beckman RB3-338 conductivity meter and a Metrohm E488 pH meter, respectively.

To determine diurnal variations, hourly measurements of dissolved oxygen and water temperature were also made on the north and south shores of the river at Cecil Ferry (R10) during each survey using an automatic monitoring/recording device. Data provided by the recorder were used to calculate oxygen saturation values.

All river water samples were collected using either a metal sampling rod or by hand. All bacteriological samples were collected at a depth of approximately 0.2 m using a sampling rod. All other samples were generally collected at mid-depth except when waters deeper than 1 m were encountered. At these latter sites, samples were collected from a depth of about 0.5 m. In the main currents or in the shallow waters towards either shore, it was not practical to employ weighted samplers as might be used in deeper, static waters. Except for the collection of shoreline samples, all river sampling was conducted from boats.

All bacteriological samples were placed in the dark inside coolers immediately after collection. Ice was not required in the coolers because of the low ambient air and water temperatures experienced during the two surveys. Water samples intended for analyses for heavy metals and trace substances, resin acid, sulphides, and phenols (eg: Table 2.3) were preserved for storage and shipment immediately upon returning to shore at the end of sampling at each transect. These samples were preserved within fifteen minutes of their collection in all instances.

Effluent samples from the Prince Albert sewage treatment plant were collected either by use of a sampling rod in the case of grab samples or by use of a heated automatic sampler for the collection of 24-hr composite samples. Grab samples of final effluent from the Prince Albert Pulp Co. were obtained using a bucket lowered into the discharge stream at a point immediately downstream of the final aeration lagoon.

All storm sewage samples were collected by use of a sampling rod or by hand.

To facilitate prompt delivery of samples to analytical laboratories, the samples were packed in coolers or in cardboard boxes and shipped by courier early in the evening of each of the first three days of each survey. All samples intended for bacteriological, nutrient, major ion, and mercury analyses were transported to the Provincial Laboratory in Regina. The remainder, for heavy metals and trace substances, phenols, resin acids, sulphides, and colour analyses were transported to the Saskatchewan Research Council laboratory in Saskatoon. On the final day of each survey the field staff delivered any additional samples from the fourth day of the surveys to the respective laboratories while returning to Regina.

2.4.1 Field Adjustments

In several instances, alterations of the originally planned sampling regime were implemented due to weather conditions and to observations made in the field pertaining to effluent plume characteristics, water depth, and presence of unexpected effluent discharges.

For example, transect R5 was relocated to a point about 50 metres upstream of the originally planned location when sewage effluent was observed early in the first survey being discharged from a bypass pipe at a point about 100 m upstream of the Prince Albert sewage treatment plant outfall (Figure 2).

Transect R8 was relocated at its first sampling in Survey 1 to a point about 100 metres downstream of the originally designated site because of a sand bar formation creating shallow water conditions on the south shore of the river opposite the pulp mill water intake.

As indicated in Table 2.1, additional sampling sites were established at Transects R5, R7, R8, R10, R11, and R12 in the second field survey in order to obtain additional data to overcome deficiencies which a review of results from the first survey had indicated and to better characterize the water quality at these transects. For example, additional sampling to obtain data regarding possible pentachlorophenol contamination originating from the storm sewer outfall at 8th Avenue East (Table 2.3) was carried out.

Also, at transect R9 immediately below the pulp mill effluent, samples were collected at a distance from the left bank of slightly less than 10 m in the second survey when it was noticed from the colour of the water that the effluent plume at that time was clearly closer to the north shore of the river than had originally been observed.

2.4.2 Data Storage and Analyses

The water quality data obtained from the study were recorded on laboratory report sheets and transcribed to data summary tables. Historical data pertaining to effluent quality and to water quality at routine sampling stations forming part of the provincial water quality monitoring network were summarized and retrieved from the Esquadat computer system and used for comparison with data related to the present study.

Mean, median, and range values for all variables as well as geometric mean values for bacteriological variables were determined for seasonal and annual summaries of historical data stored in the Esquadat system for the period 1970 - 1983. Similar calculations were made manually for data pertaining to the individual as well as the combined field surveys conducted in October and November of 1983.

Analyses of variance, using computer based procedures, were carried out for selected variables to estimate the significance of concentration variations.

3. RESULTS AND DISCUSSION

3.1 Effluent Quality

3.1.1 Prince Albert Storm Sewers

The results of bacteriological and chemical analyses of samples previously obtained from storm sewer discharges in Prince Albert in 1982 and during the autumn 1983 surveys are summarized in Appendix 3 in Tables A3.1 and A3.2, respectively. The location of each storm sewer outfall is shown in Figure 3.

The effluent discharged from the 6th Avenue West storm sewer was of exceptionally poor quality on both sampling occassions. This effluent was characterized by high levels of indicator bacteria (eg: 46,000 - 300,000 TC/100 mL; 2,000 - 69,000 FC/100 mL; 85,000 - 770,000 FS/100 mL), high BOD (700 mg/L), high dissolved organic carbon (195 - 244 mg/L), high TSS (129 - 284 mg/L), TKN (7.5 - 14 mg/L), and total phosphorus (2.2 - 4.2 mg/L). With respect to temperature, BOD, dissolved organic carbon, TSS, VSS, and pH, the concentrations observed for this storm sewer effluent exceeded those observed in the effluent discharged from the Prince Albert sewage treatment plant (Table 3.1). The flow from the storm sewer discharge conduit was relatively low on both sampling occasions and in both instances, the storm sewer effluent possessed a strong beer odour and a temperature of 24°C. On the second sampling occasion fragmented beer bottle labels were also observed in the effluent. These results indicate the effluent to be at least in part derived from the local brewery. The relatively high temperature of the effluent suggests that the wastewater had very recently been released into the 6th Avenue West storm sewer. Higher levels of many of these variables were observed in wastewater from this storm sewer in samples obtained in 1982 (Table A3.1).

Low flow of effluent was also noted for the sewer outfall west of 6th Avenue West during the first survey with higher flow being observed in the second survey. This increase in discharge from this sewer was believed to be related to the discharge of filter backwash from the Prince Albert water treatment plant (Figure 3). The discharge of backwash water may account for the significantly lower levels of indicator bacteria, TKN, ammonia, total phosphorus, orthophosphorus, and conductivity observed in the sample from the second survey. The observed reduction in concentrations of these variables was likely attributable to dilution of the normally present storm water with backwash water.

Samples of effluent from the 6th Avenue East storm sewer discharge contained moderate levels of indicator bacteria (eg: 6,000 - 45,000 TC/100 mL; 1,200 - 5,200 FC/100 mL;

620 - 740 FS/100 mL), a relatively high levels of nitrate nitrogen (10.1 - 12.2 mg/L), moderately high conductivity (2,560 - 2,600 uS/cm) and relatively high chloride (130 - 134 mg/L) in both surveys. Field staff reported hydrocarbon odour and grey colouration in the sample obtained in Survey 1 and the presence of moderate septic odour, fragmented toilet tissue and light green colouration in the Survey 2 sample. Flows were reported to be similarly low in both surveys. Similar observations with regard to these variables were also made in 1982.

Flows of effluent from the 8th Avenue East and 8th Avenue West storm sewers were reported to be low in both surveys. Except for relatively high nitrate nitrogen levels at both sites, these effluents contained no significantly high levels of other measured variables. However, effluent from the 8th Avenue East storm sewer was reported to possess a phenolic odour on both sampling occasions and pentachlorophenol (PCP) was detected at a level of 0.065 mg/l in the second survey sample. When this site was sampled in September of 1982 there was visible black oil on the surface of the water. The results of analyses of a sample obtained at that time showed a PCP content of 15 mg/l. The lower level of PCP detected during the autumn 1983 study may reflect declining levels of PCP in ground water infiltrating the storm sewer. The source of the PCP was likely the former wood preserving operation located on land drained by the 8th Avenue East storm sewer (Saskatchewan Forest Products Corporation 1982).

The City of Prince Albert has agreed to construct drainage works in the affected area to divert PCP-contaminated ground water from the storm sewer to the sanitary system by 1985. This would redirect water contaminated with PCP to the municipal sewage treatment plant and prevent its direct entry in to the river at the 8th Avenue East storm sewer outfall.

In 1980, the City installed a containment system at the storm sewer outfall to trap PCP-contaminated oils. Observations made by Saskatchewan Environment field staff during the autumn 1983 study indicated that although surface oils were retained by the containment structure (hay bails) some oil was visually observed to pass through the structure into the river. During high flow periods in the river the containment structure may be submerged.

In order to prevent direct entry of PCP to the river construction of the drainage works to direct contaminated ground water to the municipal sanitary system should be completed as soon as possible. In the interim the City should diligently carry out regular inspection and maintenance of the containment structure. Dead floating plant debris was also observed in the effluent from this storm sewer, but only in the second survey in 1983. However, in 1982 both of the 8th Avenue storm sewers' discharges contained high levels of nitrate nitrogen (3.75-14.5 mg/L) and generally higher bacterial levels than were observed in the 1983 surveys.

An approval to operate the storm sewage works was issued to the City of Prince Albert in 1970. An operating condition was included on the certificate of approval which specified that sanitary sewage and industrial wastes were not to be directed into the storm sewer system (Saskatchewan Water Resources Commission Certificates No. 281, August 19, 1970).

The results of the current study indicate the presence of domestic sewage and/or industrial wastes in several storm sewers in Prince Albert. The presence of such wastes is a violation of the condition included in the certificate of approval to operate the storm sewer system. Discharge of these untreated wastes, particularly PCP, to the river is undesirable.

3.1.2 Prince Albert Sewage Treatment Plant Effluent

In 1968 the City of Prince Albert was advised by the Saskatchewan Water Resources Commission that a minimum of primary treatment would be required before municipal sanitary sewage could be discharged to the North Saskatchewan River. The City made a commitment to provide the required level of sewage treatment and in 1970 the Commission issued an approval for construction of a primary sewage treatment facility.

The treatment system was designed to handle average sewage flows of 15,600 m^3/day and peak flows of 31,200 m^3/day. The system design included facilities for primary clarification, concentration and incineration of primary sludge, and discharge of treated effluent through a submerged diffuser outfall to the south shore of the North Saskatchewan River (56.3 Km above the confluence). A chlorine contact chamber was included in the plant design to provide for future disinfection of the effluent. The treatment plant was constructed with these design features and became operative in 1972. The plant provides primary treatment, without disinfection, for sewage and wastewater collected in the sanitary system of the portion of the city on the south side of the river. On the north side of the river only a portion of the residential area is serviced to provide sewage treatment. In this area a septic tank of 81.8 m^3 capacity was approved for construction in 1971 (Saskatchewan Water Resources Commission Certificate No. 754, August 25, 1971) to provide primary treatment of sewage to the Hazeldell residential area. The system was designed to serve a maximum population of 300 people. Non disinfected effluent from the septic tank is discharged to the north shore of the river at 3 Avenue Northwest (62.0 km above the river confluence) which is approximately 0.4 km upstream of the Highway No. 2 bridge. The volume of effluent discharged from the septic tank was estimated to be about 60 - 65 m^3/day.

The October and November 1983 survey results of general chemical, bacteriological, and heavy metal and trace substances analyses of Prince Albert sewage treatment plant effluent as well as calculated daily effluent loadings of selected variables and a summary of historical data are contained in Tables A4.1 - A4.4 of Appendix 4. Ranges of values for selected variables determined in these effluent samples for both surveys and average daily loadings for selected variables in the survey are summarized in Table 3.1.

In nearly all instances the values for the variables listed in Table 3.1 fell within the range of values for corresponding historical data (Table A4.4) indicating that the October/November 1983 survey results were typical with respect to the quality of effluent discharged from the sewage treatment plant. The survey results pertaining to heavy metal and trace substances (Table A4.2) were also similar to those recorded for the effluent in the past (Table A4.4).

The average loadings for total suspended solids (TSS), total nitrogen (TN), total phosphorus (TP), and chloride (Table 3.1) were similar in both surveys while calculated loadings with respect to biochemical oxygen demand (BOD) and dissolved organic carbon (DOC) were significantly higher during the second survey. However, these latter loadings were similar to those pertaining to calculated loading values for the historical data for BOD and DOC (Table A4.4). The loadings based on the 1983 survey results for BOD were slightly higher than that calculated for historical data. Conversely, the 1983 survey-related loadings values for TSS and chloride were considerably less than those calculated on the basis of historical data for these two variables.

The indicator bacteria levels observed in the primary effluent leaving the sewage treatment plant were within the ranges for these variables recorded for historical data. These levels are not atypical of undisinfected primary sewage effluent. Marked reductions in indicator bacteria levels in the effluent can be achieved by chlorination disinfection. Since a chlorine retention chamber was

TABLE 3.1
PRINCE ALBERT SEWAGE TREATMENT PLANT SELECTED EFFLUENT CHARACTERISTICS OCTOBER AND NOVEMBER 1982 SURVEYS

Variable (in mg/L Unless Noted)	Range - Grab and Composite Samples * for Both Surveys
Sewage Flow, m^3/d	21,005 - 25,301
Total Coliforms, /100 mL	440,000 - 41,000,000
Fecal Coliforms, /100 mL	Q130,000 - G6,900,000
Fecal Streptococci, /100 mL	77,000 - Q2,900,000
Temperature, °C	14 - 19
Biochemical Oxygen Demand	50.0 - 170.0
Dissolved Organic Carbon	20 - 45
Total Suspended Solids	46 - 87
Volatile Suspended Solids	38 - 56
Nitrogen, Total Kjeldahl	25.0 - 32.5
Nitrogen, Nitrate	L0.03 - 0.03
Nitrogen, Ammonia	17.50 - 21.00
Phosphorus, Total	4.25 - 6.25
Phosphorus, ortho	2.25 - 4.97
pH (field), units	7.5 - 7.7
pH (lab), units	7.4 - 7.7
Specific Conductance, uS/cm	1,280 - 1,840
Total Alkalinity, as $CaCO_3$	292 - 325
Chloride	126 - 292

Variable (in kg/d)	Average Loadings for Composite Samples * October 17 - 19	Oct 31 - Nov 2
Biochemical Oxygen Demand	2,828	3,953
Dissolved Organic Carbon	697	1,026
Total Suspended Solids	1,561	1,349
Nitrogen (TKN + NO_3-N)	653	729
Phosphorus, Total	105	145
Chloride	3,583	3,385

* data based on results of analyses of 8 samples

provided during establishment of this sewage treatment facility, disinfection of the effluent could likely be implemented without significant additional expenditures or facility modification.

3.1.3 Prince Albert Pulp Company Effluent

The Prince Albert Pulp Company (PAPCO) mill produces bleached kraft softwood pulp for the domestic and foreign markets. Turpentine and tall oil are also produced at the mill as byproducts of pulp production. Most of the mill wastewater is generated by the pulp bleaching process. This wastewater plus domestic sewage, and water entering floor drains in the mill, is directed to a primary settling pond. Overflow from the primary pond enters a large (13.4 hectares) secondary aeration lagoon. Retention time of the wastewater in the treatment system is several days. The rate of discharge of the final effluent from the aeration pond varies with mill operations and was estimated to be in the range of 84,300 to 95,500 cubic metres per day during the autumn, 1983 surveys. The effluent enters the North Saskatchewan River through a diffuser outfall pipe located 2.7 Km below the water intake to the mill (Figure 2).

The wastewater treatment system currently in use at the mill was constructed in 1976 and is presently operated under approval of Saskatchewan Environment (Saskatchewan Environment Certificate No. 1818, October 11, 1983). The conditions of operation specified in the approval include requirements for extensive monitoring of the wastewater effluent as well as water quality testing of the river at the intake pipe and at the northern portion of the river at the Cecil Ferry crossing (R10, 9.5 Km below the effluent outfall).

The October and November 1983 survey results of general chemical, bacteriological, and heavy metal and trace substances analyses of the pulp mill final effluent as well as calculated daily effluent loadings of selected variables derived from the 1983 surveys and from historical data have been summarized in Tables A5.1 - A5.4 of Appendix 5. . Ranges of values for selected variables determined in the two 1983 surveys and average daily loadings for selected variables in each survey are summarized in Table 3.2.

The average daily loadings for BOD, nitrogen (TKN) and total phosphorus in the final effluent were similar for both surveys (Table 3.2). An increase in loading was noted for DOC from Survey 1 to Survey 2 which involved an additional loading of about 330 kg DOC/day (47% increase). However, decreased loadings were observed with respect to TSS and chloride in the second survey. Differences in the results of several of these variables between the two surveys may relate to sample variability or the change in the type of raw material used at the mill for pulp production during the fall survey period.

With respect to calculated loadings based on data for a previous one-year period (Table A5.4), it should be noted that the 1983 survey results for nitrogen (TKN) were significantly higher than that pertaining to historical data. Conversely, the 1983 survey related loadings with respect to BOD and total phosphorus were lower than those calculated from historical data. This may relate to improvements in the effluent quality brought about by operation of the secondary treatment system since 1976.

Calculated loadings for the 1983 surveys with respect to resin acids (Table A5.3) were nearly an order of magnitude less than that noted in the historical data (Table A5.4). There was a trend towards higher loading values for the 1983 survey with respect to sulphides although the estimated historical loading value (150 kg/day) fell within the range of values pertaining to each day of the 1983 surveys.

TABLE 3.2

PRINCE ALBERT PULP CO.

SELECTED EFFLUENT CHARACTERISTICS

OCTOBER AND NOVEMBER 1983 SURVEYS

Variable (in mg/L Unless Noted)	Range - Grab and Composite Samples * for Both Surveys
Effluent Flow, m^3/d	84,300 - 95,000
Total Coliforms, /100 mL	600,000 - 3,300,000
Fecal Coliforms, /100 mL	150,000 - Q2,140,000
Fecal Streptococci, /100 mL	L10 - 10
Temperature, °C	18.0 - 24.0
Biochemical Oxygen Demand	30.0 - 55.0
Dissolved Organic Carbon	92 - 248
Total Suspended Solids	56 - 85
Volatile Suspended Solids	46 - 68
Nitrogen, Total Kjeldahl	6.5 - 8.0
Phosphorus, Total	0.70 - 0.85
pH (field), units	7.4 - 7.5
pH (lab), units	7.2 - 7.5
Specific Conductance, uS/cm	2,490 - 4,560
Total Alkalinity, as $CaCO_3$	264 - 317
Chloride	560 - 670
Colour	1,100 - 1,300
Resin Acids	0.28 - 0.8
Sulphides	0.64 - 4.1
Mercaptans	0.7 - 6.1

Variable (in kg/d)	Average Loadings for Grab Samples October 17 - 19	 Oct 31 - Nov 2
Biochemical Oxygen Demand	4,011	4,165
Dissolved Organic Carbon	14,689	21,156
Total Suspended Solids	7,585	6,126
Nitrogen, TKN	689	662
Phosphorus, Total	77	70
Chloride	61,721	50,512

* data based on results of analyses of 6 samples

L = less than
Q = best estimate

There were notable differences between the 1983 survey results and historical data with respect to individual variable concentrations and measurements. For instance, the historical daily mean value for conductance of the final effluent was 1,860 uS/cm while significantly higher values (2,500 - 4,600 uS/cm) were recorded for each day of the 1983 surveys (Table A5.1). Conversely, colour was recorded at a mean value of 2,500 units among historical data but was observed to be consistantly less intense (1,100 - 1,300 units) on each day of the two surveys. Improvements in wastewater treatment at the mill since 1976 may account for some of these differences.

Between the two 1983 surveys, the temperature of the final effluent ranged from 18°C to 23°C. There were coincidental increases in total alkalinity, DOC, and resin acids and mercaptan concentrations and a decrease in concentrations of chloride and resin acids in the final effluent between the two surveys. Again, these differences between results of the two surveys may reflect sample variability or the change in type of raw material utilized at the mill during the autumn, 1983 survey period.

There was also a tendency towards higher concentrations of indicator coliform bacteria (TC, FC) in individual samples of final effluent taken in the second survey. These values ranged from 2.1 - 3.3 x 10^6/100 mL for TC and 1.1 - 2.1 x 10^6/100 mL for FC in the second survey (Table A5.1). Fecal streptococci levels in both surveys were very low (eg: 10 FS/100mL) thereby casting doubt as to the fecal origin of the high total and fecal coliform levels observed in the final effluent (eg: further explanation is provided in the following paragraphs). These results, based upon membrane filtration analyses for TC and FC were generally much higher than geometric mean values calculated for historical data concerning the final effluent and based upon a different (most probable number) analytical procedure. The historical data, however, consisted largely of non-absolute values due to insufficient dilution of the sample during analyses and a subsequent result generally qualified as "greater than" some multiple of 2,300/100 mL.

During the autumn of 1983 about 300 employees were present at the mill. It is difficult to determine the exact amount of sanitary wastewater produced by the mill staff, however, since the sewage enters the industrial wastewater collection system at several locations and the volumes of sanitary wastewater are not monitored. If one assumes, however, that about 100 litres of sanitary wastewater is generated by each employee each day then the sewage contribution to the mill wastewater system during the study period would have been about 30,000 L per day. The expected direct contribution of FC bacteria to the final effluent (assuming complete mixing and survival of the fecal-derived FC) would result in a final effluent concentration of only about 400 FC/100 mL. This suggests that the sewage added to the industrial wastewater system at the mill may contribute directly only about 0.2 per cent of the minimum FC concentration (150,000 FC/100 mL) observed in the final effluent during the autumn 1983 surveys (Table 3.1). The observed higher levels of FC in the final effluent were therefore very likely the result of growth of enteric bacteria in the wastewater treatment system.

There is considerable evidence pertaining to pulp mill effluents and effluent receiving waters which demonstrates interferences with the coliform (TC and FC) analyses by bacteria which are not of fecal origin. For instance, studies carried out on pulp mill aeration ponds and effluents in the Fort Frances area in Ontario (Environment Canada 1972, 1973) demonstrated a low incidence of the classical fecal coliform bacteria, Escherichia coli, fecal streptococci (FS), and salmonellae in pulp mill effluents.

FS bacteria were apparently unable to multiply in the pulp mill aeration lagoons examined (Environment Canada 1973). However, a very high proportion of the species Enterobacter, and to a lesser degree Klebsiella sp., comprised the high coliform and fecal coliform populations observed in aeration ponds and effluents. The studies concluded that strains of Enterobacter as well as other enteric species of bacteria grew in the mill effluent particularly during the warmer summer season. On these bases, the high observed TC and FC populations were concluded to be due to growth of strains of bacteria which mimic E. coli in its biochemical reactions in standard test procedures and not because of sanitary wastes (eg: fecal pollution). It is plausible that FC bacteria contributed to the PAPCO wastewater system through additions of domestic wastes, together with FC and enteric species already in the system (eg: of aquatic and terrestrial origin), could serve as a source of inoculum of enteric bacteria which may grow in the aeration lagoons. It is unlikely, however, that pathogenic species such as the salmonellae would also grow in the lagoons (Bell et al 1978) but they may be present at very low concentrations due to the entry of untreated fecal wastes to the treatment system.

Similar studies in the United States (Caplenas, Kanarek &

Dufour 1981) and Scandinavia (Niemela & Vaatanen 1982) have shown the proliferation of Klebsiella strains in pulp and paper mill effluents with the resultant effect that standard analyses of the effluents or receiving waters indicated high levels of fecal coliform bacteria even though no significant sources of fecal contamination were apparent. Bell et al (1978) reported a shift in the composition of the coliform population to the advantage of strains of Klebsiella in the section of the North Saskatchewan River immediately influenced by the pulp mill effluent. They did not, however, observe high levels of either coliform group nor FS in the mill effluent nor did they observe evidence of the proliferation of coliform bacteria in the mill aeration ponds.

This latter observation by Bell et al (1978) conflicts with the findings of the present study (Table 3.2) and with historical data pertaining to the pulp mill effluent (Table A5.4).

As part of the present study selected cultures of fecal coliform bacteria isolated from the pulp mill effluent, as well as from river water samples, were identified to species. The results of this identification work are summarized in Appendix 6. Only two isolates of FC bacteria, from membrane filters through which the smallest quantities of pulp mill effluent were filtered, were identified. Both isolates were Klebsiella pneumoniae suggesting that at least a significant portion of the FC population observed in the mill effluent in the 1983 surveys may have been due to growth of this enteric species in the wastewater rather than as a result of direct fecal contamination. The absence of significant levels of fecal streptococci in the effluent (Table 3.2) supports this conclusion even though a relatively small quantity of domestic sewage is added to the mill wastewater. The sanitary wastes generated at the pulp mill are mixed with industrial effluent at several locations within the mill complex prior to their entry in the wastewater lagoons. The sanitary wastes, therefore, likely could not be readily isolated, from the industrial wastewaters for purposes of separate treatment.

It should be noted, however, that although the FC results for the mill effluent may not signify fecal pollution, the high levels of the enteric bacteria contributing to the observed elevated FC levels nevertheless may contribute to a degradation of quality in the effluent receiving waters (Caplenas et al 1981).

Klebsiella pneumoniae is an opportunistic pathogen, but the significance of high levels of this organism derived from pulp mill effluents to human health if unknown (Caplenas et al 1981). The impact of Klebsiella on the recreational or consumptive use of the receiving waters for pulp mill effluents containing high levels of this bacteria is therefore uncertain.

Bell et al (1976) reported that 46% of the FC in the Prince Albert pulp mill effluent and 43.4% of the FC in the North Saskatchewan River were resistant to one or more antibiotics. They speculated that R-factor transfer may occur in the aquatic environment, and recently such transfers have been demonstrated among bacteria in a sewage treatment plant (Mach & Grimes 1982). Other studies (eg: Niemi, Sibakov & Niemela 1983) have shown a strong correlation between the relative frequency of Klebsiella in aquatic populations of coliform bacteria and the incidence of resistance to some antibiotics possessed by the coliform population. Although no direct evidence is available, it is conceivable that the addition of relatively small quantities of domestic sewage to the aeration ponds of the Prince Albert pulp mill could increase the likelihood that aquisition of the antibiotic resistance factors would occur among the enteric species (eg: Klebsiella) which proliferate in the mill effluent.

3.2 River Water Quality

A detailed summary of field measurements and bacteriological, chemical, and heavy metal and trace substance data for all river water samples obtained from transect monitoring stations in the October/November 1983 surveys is presented in Appendix 7. The following addresses the major observations and findings with regard to these analytical results.

3.2.1 Bacteriology

3.2.1.1 Background Discussion

In Saskatchewan the bacteriological quality of surface water is assessed using various objectives for indicator bacteria (TC and FC). These bacteriological surface water quality objectives are as follows: (Saskatchewan Environment 1975.)

a) In waters to be withdrawn for treatment and distribution as a potable supply or used for outdoor recreation other than direct contact, at least 90 percent of the samples (not less then five samples in any consecutive 30-day period) should have a total coliform density of less then 5,000 per 100 mL and a fecal coliform density of less then 1,000 per 100 mL. (The Maximum Permissible Limit of total coliform organisms in a single sample shall be determined by the Department based on the type and degree of pollution and other local conditions existing within the watershed.)

(b) In waters used for direct contact recreation or vegetable crop irrigation the geometric mean of not less than five samples taken over not more than a 30-day period should not exceed 1,000 per 100 mL total coliforms, nor 200 per 100 mL fecal coliforms, nor exceed these numbers in more than 20 percent of the samples examined during any month, nor exceed 2,400 per 100 mL total coliforms on any day.

At present Saskatchewan does not have a surface water quality objective concerning the fecal streptococci (FS) indicator group, but analyses for these bacteria are routinely conducted on surface water samples to provide additional information about the origins and signifcance of perceived fecal pollution that may be suggested by high levels of the other indicator bacterial groups, TC and FC.

These indicator bacteria groups have been the subject of considerable discussion because of inherent difficulties in the standard analytical procedures used for their enumeration. It is beyond the scope of this report to extensively review the literature pertaining to the deficiencies in the indicator concepts and test procedures, but attention will be drawn to specific shortcomings as they relate to water quality assessment of the North Saskatchewan River.

Total coliforms (TC) are arbitrarily defined as bacteria which grow and produce specific biochemical reactions on or in defined growth media at 35°C. They are comprised mainly of species of the enteric genera *Escherichia*, *Klebsiella*, *Citrobacter*, and *Enterobacter*. While species of *Escherichia* (eg: *E. coli*.) are believed to be restricted in origin to the intestinal tract of warm-blooded animals, species of the other genera may be derived from various sources such as soil and vegetation as well as from human and animal feces. Their presence at high levels in a surface water is indicative of poor water quality although their presence may not necessarily relate to fecal pollution or the probable presence of pathogenic bacteria.

Fecal coliform (FC) bacteria may be considered a subset of the TC population and are generally considered to be comprised of species of Escherichia and to a lesser extent, Klebsiella. They too are arbitrarily defined on the basis of biochemical reactions on or in defined media incubated at an elevated temperature (eg: 44.5°C). Their presence in water are generally considered as indicative of recent contamination by fecal material and of the potential presence of pathogenic bacteria, most notably the salmonellae.

The fecal streptococci (FS) indicator group is comprised of several species of the genus Streptococcus which inhabit the intestinal tracts of humans and warm blooded animals. Generally FS are present in the feces of animals (eg: cattle, poultry, pets, rodents) at higher densities than are members of the FC group. Their relative abundance in a water body compared to that of FC has been employed to determine the relative contributions of human or animal fecal material (eg: the FC/FS ratio). However, as is the case with TC and FC, contributions of FS from diffuse sources such as soil, and plant debris can alter the numerical relationship between FC and FS which may sometimes be observed in feces or untreated sewage. Also, due to differential rates of die-off in water and to possible growth of some FC strains in water, the FC/FS ratio is of very limited usefulness in describing the origins of perceived fecal contamination in surface waters. Nevertheless the detection of FS at high levels is usually indicative of a fecal contribution to a surface water and their concurrent determination with the FC group provides supportive evidence of the fecal origin of the FC that may be detected. Unlike the coliform groups, species of the FS group are not considered capable of growth in aquatic environments under normal conditions.

3.2.1.2 Survey Observations

During the October/November 1983 surveys of the North Saskatchewan River, high levels of all indicator groups were observed across river transects below the City of Prince Albert. The geometric mean data pertaining to TC, FC, and FS levels detected along each transect for both surveys are shown in Figure 4. In Figure 4 the bacteriological geometric mean data has been plotted on a logarithmic scale against transect locations at various distances downstream of transect R1. It is evident from this figure that bacteriological water quality upstream of the City of Prince Albert including that at the intake for the municipal water supply was suitable for all use purposes addressed in the existing provincial surface water quality objectives for the TC and FC variables.

A septic tank sewage outfall is located on the north shore of the river just upstream of transect R2 (Appendix 1). Indicator bacteriological levels in the anticipated effluent plume towards the north side of transects R2 and R3, however, were quite similar to background levels in this upper portion of the river reach under study. These findings indicate the impact of the septic tank effluent to be unmeasurable with respect to indicator bacteria variables.

On the basis of geometric mean calculations for indicator bacteria densities along transects, the impact of the municipal sewage effluent discharges was not readily apparent at transect

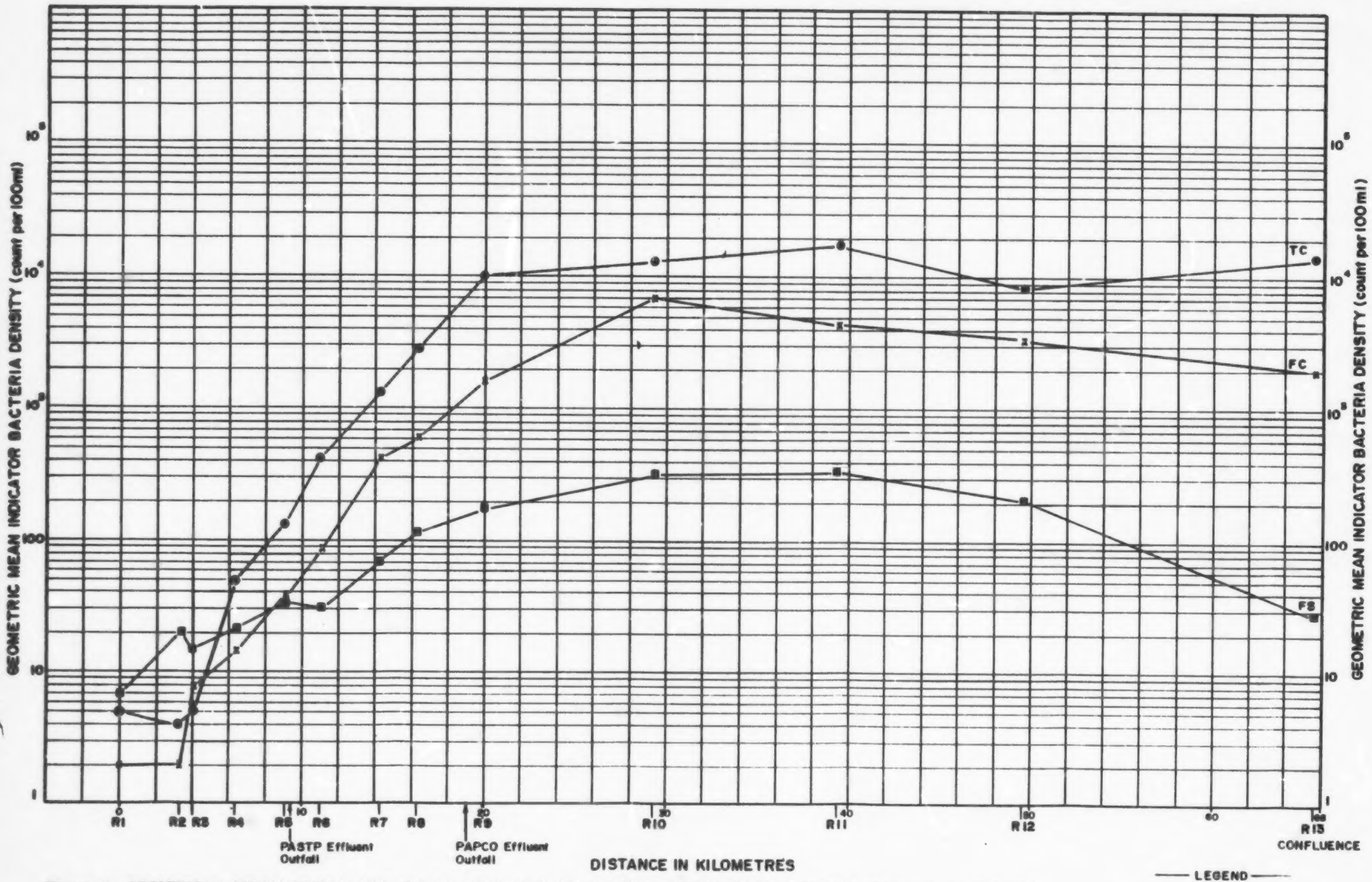


Figure 4 GEOMETRIC MEAN TOTAL AND FECAL COLIFORM AND FECAL STREPTOCOCCI DENSITIES (count per 100 ml) ACROSS TRANSECTS OF THE NORTH SASKATCHEWAN RIVER DURING THE PERIOD OCT. 17 - NOV. 3, 1983*

R6 located several kilometres downstream. However, geometric mean values for TC and FC began to exceed existing surface water quality objectives pertaining to recreational and irrigational uses at transect R7 (5.1 km below outfall). From R7 to the confluence (R13), the TC and FC geometric mean levels exceeded the provincial objectives for these water uses. In terms of use of the river for potable supply after treatment the TC and FC geometric mean levels for all transects from R9 to the confluence exceeded the existing provincial surface water quality objective. These findings are in agreement with those made previously by Bell et al (1976) regarding bacteriological water quality limitations on use of the North Saskatchewan River below Prince Albert.

The concurrent increases in FS bacteria in the river below Prince Albert are indicative of a fecal origin for at least a portion of the TC and FC population enumerated in the surveys. The data from individual samples obtained along each transect in the two 1983 surveys were also evaluated with regard to the frequency of specific levels of TC or FC bacteria exceeding the surface water quality objectives for water used for contact recreation. Table 3.3 demonstrates that from transect R5 to the confluence, more than 20 percent of the samples at each transect exceeded the objective level for TC (eg: 1,000 TC/100 mL) and this frequency increased progressively in a downstream direction. Similarly, the proportion of samples with TC densities exceeding the objective level for single samples (eg: 2,400 TC/100 mL) also increased progressively from R4 to the confluence. Also, the proportion of samples with TC exceeding 5,000/100 mL was in excess of 25 percent for single samples from R6 to the confluence.

A similar downstream progression in the relative frequency with which FC densities exceeded the objective level of 200 FC/100 mL in more than 20 percent of samples from each transect was also apparent. Also, from R6 (about 1.6 Km below the sewage outfall) to the confluence the objective level pertaining to use of the water for potable supply (1,000 FC/100 mL) was exceeded in 25 to 87.5 percent of the samples. These data are shown in Table 3.4.

TABLE 3.3

SUMMARY OF TOTAL COLIFORM (TC) RESULTS FOR SAMPLES COLLECTED FROM TRANSECT STATIONS ALONG THE NORTH SASKATCHEWAN RIVER NEAR PRINCE ALBERT DURING THE PERIOD OCTOBER 17 - NOVEMBER 3, 1983

Sampling Transect	Number of Samples Analysed	Samples with TC Exceeding 1,000/100 mL		Samples with TC Exceeding 2,400/100 mL		Samples with TC Exceeding 5,000/100 mL	
		Number	Percentage	Number	Percentage	Number	Percentage
R1	6	0	0	0	0	0	0
R2	3	0	0	0	0	0	0
R3	4	0	0	0	0	0	0
R4	9	1	11.1	1	11.1	0	0
R5	22	5	22.7	3	13.6	2	9.1
R6	8	2	25	2	25	2	25
R7	18	11	61.1	8	44.4	6	33.3
R8	34	25	73.5	20	58.8	16	47.1
R9	20	19	95	18	90	15	75
R10	25	23	92	21	84	19	76
R11	8	8	100	8	100	8	100
R12	7	7	100	7	100	5	71.4
R13	3	3	100	3	100	2	66.7
Totals	167	104	62.3	91	54.5	75	44.9

*Analyses performed using membrane filtration technique.

TABLE 3.4

SUMMARY OF FECAL COLIFORM (FC) RESULTS FOR SAMPLES COLLECTED FROM TRANSECT STATIONS ALONG THE NORTH SASKATCHEWAN RIVER NEAR PRINCE ALBERT DURING THE PERIOD OCTOBER 17 - NOVEMBER 3, 1983

Sampling Transect	Number of Samples Analysed	Samples with FC Exceeding 200/100 mL		Samples with FC Exeeding 1,000/100 mL	
		Number	Percentage	Number	Percentage
R1	6	0	0	0	0
R2	3	0	0	0	0
R3	4	0	0	0	0
R4	9	2	22.2	0	0
R5	22	4	18.2	2	9.1
R6	8	2	25	2	25
R7	18	13	72.2	6	33.3
R8	34	26	76.5	14	41.2
R9	20	19	95	11	55
R10	25	24	96	21	84
R11	8	7	87.5	7	87.5
R12	7	7	100	5	71.4
R13	3	3	100	2	66.7
Totals	167	107	64.1	70	41.9

*Analyses performed using membrane filtration technique.

These findings support the observation that the levels of TC and FC bacteria in much of the North Saskatchewan River below the City of Prince Albert generally exceed the existing surface water quality objectives for these variables pertaining to vegetable crop irrigation, contact and noncontact recreation, and potable supply after treatment. However, of these uses only that related to noncontact recreation (eg: fishing, canoeing, boating, camping) is believed to occur to any significant degree in the downstream reach of the river at present.

A more detailed evaluation of the bacteriological data derived from individual sampling sites along river transects was also carried out in order to determine the mixing characteristics and associated bacterial concentrations of storm water, sewage effluent, and pulp mill effluent introduced to the river. The TC, FC, and FS bacteriological data, based upon geometric mean values concerning individual sites along river transects R5 - R10, are shown in Figures 5, 6 and 7, respectively. These figures have bacteriological geometric mean values plotted on a logarithmic scale for transect sampling sites located 10 m from either shore and at relative distances of .25, .5 and .75 times the width of the river from the south shore.

In each figure it is evident that levels of indicator bacteria were relatively low at R5, immediately upstream of the municipal sewage outfall. In each figure as well the indicator bacteria levels can be seen to haved increased dramatically at the station 10 m from the south shore at transect R6 in direct response to the sewage effluent plume. Relatively low levels of indicator bacteria at the quarter distance stations show that the sewage effluent had undergone little lateral dispersion between the sewage outfall and R6 (a distance of 1.6 Km). The levels of TC and FC observed at the 10 m south shore transect station at R6 were well in excess of provincial water quality objectives for recreational, irrigational, or potable supply usage.

At R7 (4.9 Km below the outfall) there was evidence of lateral dispersion of the sewage effluent to the degree that the southern half of the river could be characterized as heavily

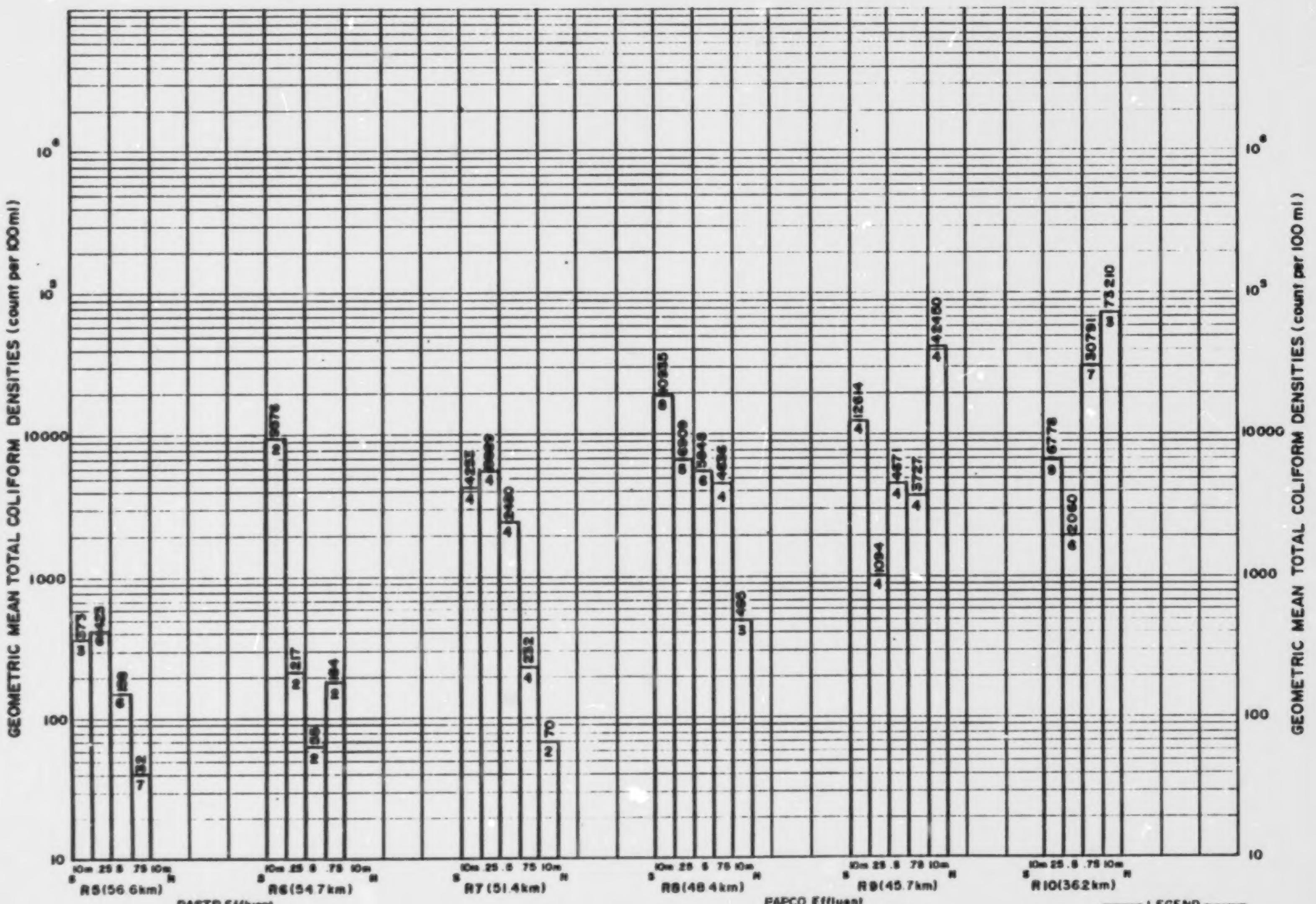


Figure 5 GEOMETRIC MEAN TOTAL COLIFORM DENSITIES (count per 100ml) at TRANSECT MONITORING SITES* ON THE NORTH SASKATCHEWAN RIVER DURING THE PERIOD OCT. 17 - NOV. 3, 1983*

LEGEND

S - SOUTH SHORE
N - NORTH SHORE
( ) NUMBERS IN BRACKETS DENOTES DISTANCE TO CONFLUENCE
- NUMERALS IN EACH BAR DENOTES NUMBER OF SAMPLES ANALYSED, EXTERNAL NUMBER DENOTES GEOMETRIC MEAN VALUES
* ALL ANALYSES BY MEMBRANE FILTRATION PROCEDURE

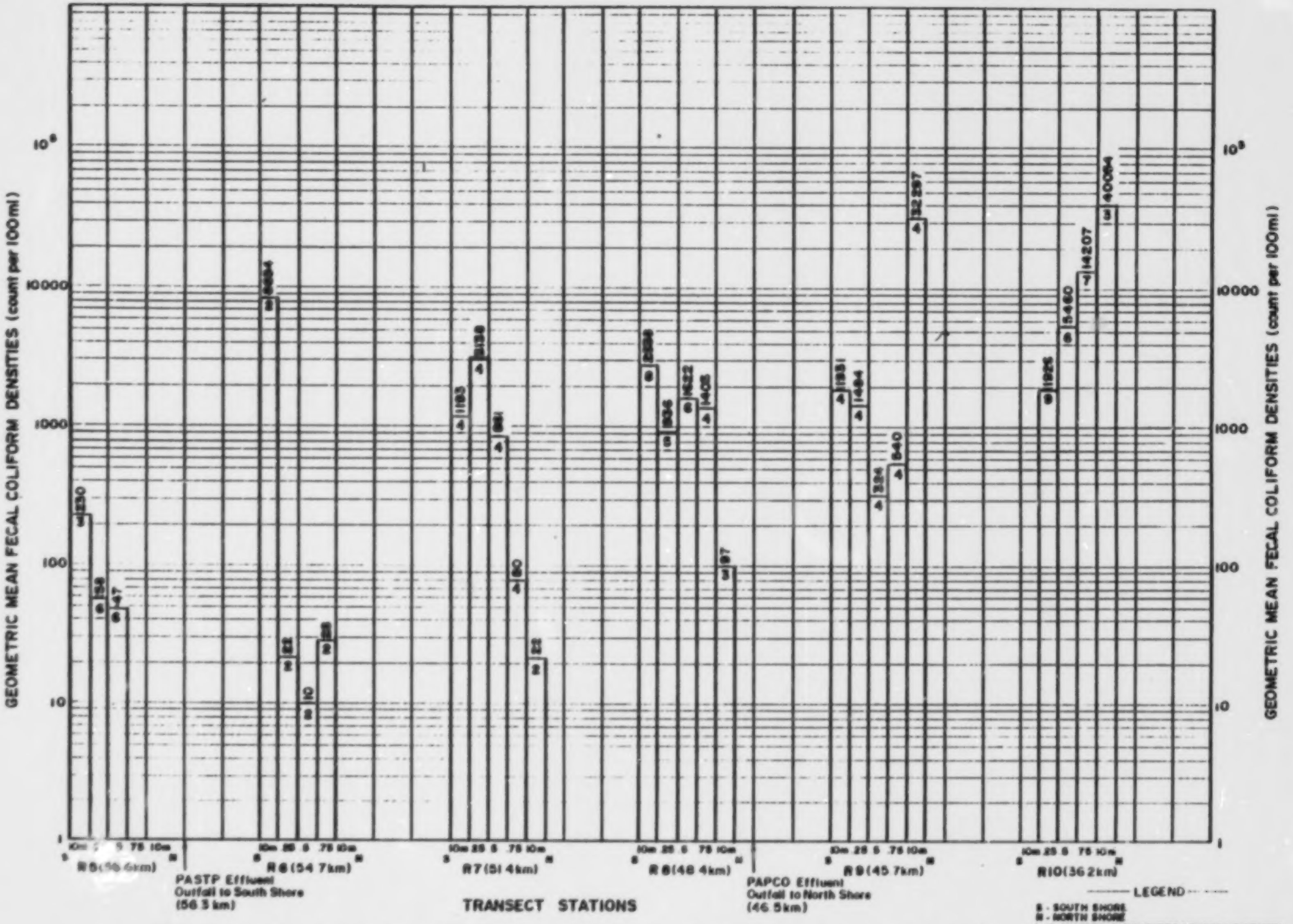


Figure 6 GEOMETRIC MEAN FECAL COLIFORM DENSITIES (count per 100ml) at TRANSECT MONITORING SITES* ON THE NORTH SASKATCHEWAN RIVER DURING THE PERIOD OCT. 17 - NOV. 3, 1983*

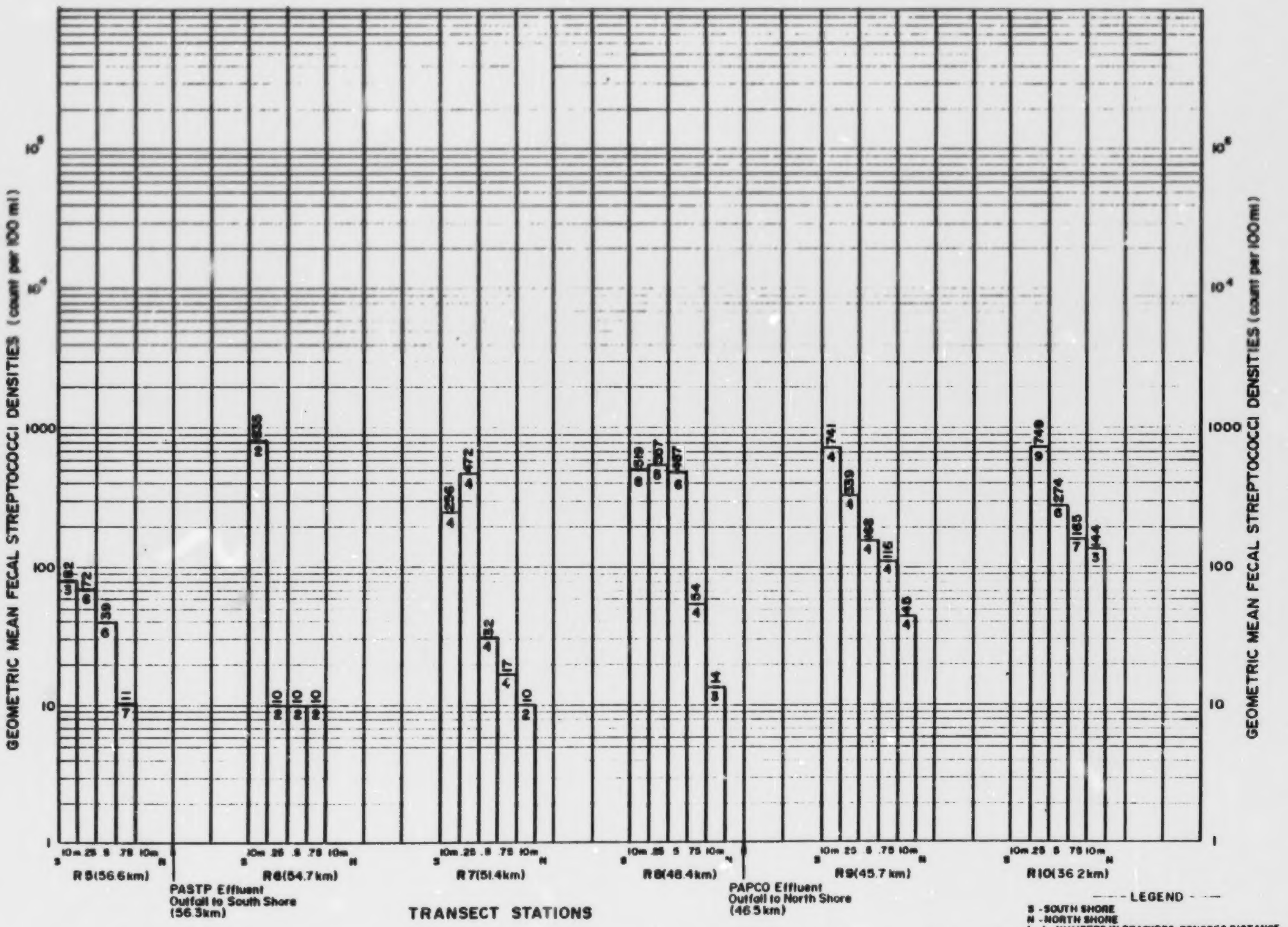


Figure 7 GEOMETRIC MEAN FECAL STREPTOCOCCI DENSITIES (count per 100ml) at TRANSECT MONITORING SITES* ON THE NORTH SASKATCHEWAN RIVER DURING THE PERIOD OCT. 17 - NOV. 3, 1983*

---- LEGEND ----

S - SOUTH SHORE
N - NORTH SHORE
( ) - NUMBERS IN BRACKETS DENOTES DISTANCE TO CONFLUENCE
- NUMERALS IN EACH BAR DENOTES NUMBER OF SAMPLES ANALYSED; EXTERNAL NUMBER DENOTES GEOMETRIC MEAN VALUE
* - ALL ANALYSES BY MEMBRANE FILTRATION PROCEDURE

contaminated with indicator bacteria. At R7 the southern half of the river was impaired for water uses related to irrigation and recreation, while the northern half of the river retained a bacteriological quality which would not impair its use for these purposes.

The data pertaining to R8 (7.9 Km below the outfall) suggest that at this location the sewage effluent had dispersed laterally over three-quarters of the width of the river from the south shore. The associated TC and FC levels in this dispersed effluent plume were in excess of the surface water quality objectives for uses involving recreation and irrigation. The FC levels exceeded the objective concerning use of water for potable supply after treatment. However, towards the north shore no such water quality impairment was evident. The pulp mill water intake is located on the north shore very near transect R8 and therefore water withdrawn for use by the pulp mill was of a quality suitable for all purposes addressed in the existing surface water quality objectives.

At transect R9 (10.6 Km below the sewage outfall), 0.8 Km below the pulp mill effluent outfall, dramatic increases in TC and FC levels, greater than those observed near the south shore of R6 below the sewage outfall, were observed at the sampling station located 10 m from the north shore. It is of interest to note that no such increase in FS was observed at this station because few FS were present in the pulp mill effluent (Table 3.1). The moderate increase in FS observed, however, might have been due to further dispersion of the sewage effluent plume towards the north shore of the river. At R9 also there was a trend towards slightly reduced levels of FC (eg: midstream station) but not of TC at transect stations in the southern three-quarters of the river. One might assume that the sewage effluent was dispersed across the river at this transect, but uniform mixing of this effluent had not yet occurred. It is difficult to determine, however, what portion of the observed TC and FC bacterial populations at the site 10 m from the north shore were derived from the municipal effluent.

Little change in observed levels of FS was detected at stations along transect R10 from those determined at R9. Since FS were at insignificant levels in the pulp mill effluent (Table 3.1) and were observed in relatively similar proportions and at increasing levels towards the south shore at both transects R9 and R10, it may be concluded that the sewage effluent was dispersed across the river but complete mixing of the effluent with river water had not yet occurred at these transects.

At R10 (20.1 Km below the sewage effluent outfall and 10.3 Km below the PAPCO outfall) there was evidence of some lateral dispersion of pulp mill effluent as indicated by an increased FC level being observed at the mid-stream and .75 RB stations. Increased TC levels at R10 were noted only for the .75 RB station.

In summary, the river water bacteriological quality at all sites upstream of transect R5 including that at the municipal water supply intake (R2) was suitable for all purposes addressed in the existing provincial surface water quality objectives for the TC and FC variables. Conversely, the results of indicator bacteria determinations on the river during the autumn 1983 surveys clearly demonstrated significant water quality impairment in terms of indicator bacteria levels which exceeded the objectives pertaining to contact and noncontact recreation, vegetable crop irrigation, and potable supply use of the water within the effluent plume between transects R6 and R9 (Figure 9). Since the sewage effluent plume within this river reach was confined to the southern three-quarters of the river this effluent did not impact on bacteriological quality of water withdrawn for industrial and consumptive purposes by the pulp mill at the mill water intake site on the north shore at transect R8.

Vegetable crop irrigation and contact recreation apparently are not current uses of the water within this river reach so the only existing water use directly affected by poor bacteriological quality within the effluent plume pertains to noncontact recreation.

There are two sites within this river reach from which water is withdrawn during the growing season for irrigation of cereal and forage crops. Both sites are located on the south shore of the river within 8 Km of the sewage effluent outfall (eg: at 51.2 and 48.8 Km above the confluence, Appendix 1). It is assumed that, when in use, the intakes for these irrigation projects would be located very close to the south shore and therefore the water withdrawn at these sites could be of poor bacteriological quality.

The existing provincial surface water quality objectives concerning the indicator bacteria variables do not apply to these types of nonvegetable crop irrigation. Current interim surface water quality objectives pertaining to FC bacteria in irrigation waters in Manitoba allow for maximum acceptable concentrations of 1,000 FC/100 mL (geometric mean value), or 200 FC/100 mL if contact of field workers with the water is probable (Manitoba Department of Environment and Workplace Safety and Health 1983). FC levels along the south shore of the river where the two irrigation projects are located exceeded the interim Manitoba objectives of 1000 FC/100 mL (Figure 6). It is not known, however, if contact of field workers with the water is likely at these locations.

Just below transect R9 the sewage effluent plume and pulp mill effluent begin to merge with the result that at all areas from R10 to the confluence (R13) can be characterized as having TC and FC levels which exceed water use objectives addressed in the current provincial surface water quality objectives (Saskatchewan Environment 1975). The effects of these effluents on water quality and use potential of the water, in terms of the FC variable, within the river reach from R5 to R10 have been summarized pictorially in Figure 9.

There was insufficient data gathered at transects downstream of R10 (36.2 Km above confluence) to permit a similar presentation of bacteriological data to be made in regard to dispersion and mixing of the pulp mill effluent. Observations by field staff, however, indicate that by visual examination the river across transect R11 was entirely brown-coloured, presumably an indication that full lateral dispersion of the pulp mill effluent had occurred by this site. The tendency for higher individual TC and FC results for the northern quarter of the river at this site (Appendix 7), however, suggests that mixing of the pulp mill effluent was not complete at this location. As depicted in Figure 4, very high levels of indicator bacteria persisted in the river as far downstream as the R12 transect and at the confluence station (R13). Transects R12 and R13 were located at respective distances of 41.3 and 56.3 Km below the sewage effluent outfall, and 31.5 and 46.5 Km downstream of the pulp mill effluent outfall. TC levels showed no significant decline from R8 to the confluence and over this reach of river only a moderate decline in FC densities was observed for the survey period. Because the time of travel for water passing the first effluent discharge near R5 to the confluence is approximately one day, no significant decreases in the population of indicator bacteria during that time period would be expected, particularly during the autumn when water temperatures were low (3-6^{o}C).

Based upon calculated loadings of indicator bacteria derived from composite sample results for the sewage effluent (Table A4.1) for the flow conditions in the river at the time of the surveys, the theoretical or expected levels of bacteria were generally an order of magnitude greater than were actually observed in individual samples taken from transect sites below the effluent outfall.. The reasons for the observed values being lower than expected are unknown but may relate to sedimentation or predation of bacteria or perhaps to sampling and analytical error. As already mentioned, significant die-off of bacteria under conditions present at the time of the study would not likely have occurred. This anomaly may suggest that higher levels of indicator bacteria might be observed at other times or under other conditions which do not favour this apparent reduction in expected levels of indicator bacteria.

Although these study results pertain to the low flow conditions characteristic of the river during autumn, it is worthy to note that similar low flow conditions can also occur in the river during the summer months (Figure 1). Similar impacts of the sewage effluent with regard to bacteriological variables could, therefore, be expected in the river during the summer when recreation and irrigation use would most likely occur. Although bacterial die-off rates might be expected to be greater during the summer than in fall or winter there would likely be little opportunity for significant reductions in bacterial levels to occur in the river reach studied since even under low flow conditions the time of travel between the sewage outfall and the confluence would be one day or less. Therefore, the observation of high levels of FC bacteria in the North Saskatchewan River at R13 (confluence) suggests that the detrimental effects of the sewage and pulp mill effluents on bacteriological water quality might also be observed in portions of the Saskatchewan River downstream of the confluence. Future recreational use of the river, and river water impounded by reservoir development on the Saskatchewan River, could be negatively influenced as a consequence.

As indicated in Section 2.3, selected FC colonies recovered from various river water and effluent samples were identified to species to determine if interferences with the FC procedure were being encountered. The results of this work are presented in Appendix 6.

A total of 22 colonies with apparently typical blue coloration were picked as target colonies and identified to species. Sixteen of these were identified as *Escherichia coli*, the classical FC. Species of *Enterobacter*, *Citrobacter*, *Klebsiella*, and *Serratia* accounted for the other six culture identifications. Another 16 colonies which would normally be enumerated as FC colonies but which possessed atypical blue colony characteristics were also identified. Eleven of these were *Klebsiella* sp, while the remainder were *Escherichia coli* (3 colonies), or species of *Enterobacter* or *Serratia*. Of the three nontarget (background) colonies identified, two were confirmed as nonenteric strains of *Pseudomonas* and the third as *Klebsiella*. These results suggest a lack of specificity in the FC membrane filtration procedure in that 18 percent of typical target colonies were neither *Escherichia* nor *Klebsiella*, the two genera normally considered to comprise the FC population. Also, since about one-third of the atypical target colonies were not of these genera, there is need to examine the procedure to determine the relevance of the results it provides in water quality assessment, since it appears to be subject to interferences by bacteria not considered to be FC and by lack of clear expression of *E. coli* as a target colony.

It is interesting to note that the apparent interference with the FC membrane filtration procedure was not restricted to areas downstream of the pulp mill effluent discharge. For instance Klebsiella, which might be considered of fecal origin, and isolates of Serratia and Enterobacter, possessing typical FC-like characteristics, were isolated from samples taken at R5, upstream of both the municipal sewage and pulp mill effluent discharges. These may have been derived from fecal sources (eg: wildlife, septic tank near north end of R2) or stormwater inputs (Figure 3) or from diffuse sources upstream which contribute to the background levels of FC observed in the river. At R10 to R13, atypical target colonies predominated among the cultures of FC selected for identification and most of these were identified as species of Klebsiella. This suggests a lack of specificity for the FC procedure with regard to analyses of surface waters not impacted upon by pulp mill effluents as well.

There is considerable literature documenting the relative dominance of Klebsiella among the FC population of pulp mill (eg: Huntley, Jones &

Cabelli 1976; Caplenas et al 1981, Niemela & Vaatanen 1982) and textile mill (Dubour & Cabelli 1976) effluent receiving waters. Bell et al (1978) also noted a shift in the composition of the FC population to the advantage of strains of *Klebsiella* in the section of the North Saskatchewan River immediately influenced by the pulp mill effluent. The cause of high levels of *Klebsiella* in receiving waters of these studies was believed to be attributable to growth of *Klebsiella* in the industrial effluent waste treatment systems. *Klebsiella* were shown to be capable of growth in pulp mill aeration ponds in Ontario (Environment Canada 1972, 1973) although their proliferation was generally limited to the summer season when temperatures of the wastewater were relatively high. In the Ontario studies the dominant FC identified were species of the genus *Enterobacter*, which were also isolated as FC in the present study.

The major consequences of the growth of these enteric species of non-fecal origin are three-fold. Firstly, because at least some strains of *Klebsiella* are opportunistically pathogenic and associated with genitourinary and upper respiratory tract infections, their presence in inordinately large numbers in recreational waters may be of health significance if the water were purposefully or accidentally consumed or inhaled. Epidemiological studies related to this issue are lacking. Contact recreational use of this reach of the North Saskatchewan River is, however, presumed to be minimal at present.

Secondly, an important consequence of the growth of _Klebsiella_ or _Enterobacter_ with _Escherichia coli_-like biochemical characteristics in pulp effluents is that it can lead to invalidation of the FC test results obtained from the analyses of such effluents and their receiving waters. In such waters the observation of high levels of FC bacteria could be erroneously perceived as indicative of recent fecal contamination with the associated presence of disease-causing microorganisms of fecal origin.

Alternate analytical procedures specific for _E. coli_, might better be applied to pulp mill effluents and their receiving waters to assess the quality of these waters in terms of associated fecal contamination and related water quality concerns. E. coli apparently is not able to multiply in the pulp mill wastewater. A modified procedure of that developed by Dufour, Strickland and Cabelli (1981) is currently in use in Ontario for these purposes.

Thirdly, the potential for development of high numbers of antibiotic resistant enteric bacteria and the exchange of the antibiotic resistance factors with waterborne pathogenic genera such as Salmonella may have indirect health implications. The likelihood of this occurring can be assumed to be greatest where human fecal wastes are introduced to wastewaters containing high levels of enteric bacteria capable of donating or receiving the antibiotic resistance factors. This may be a subject for consideration in the distant future but at present there is no evidence that such a situation would impact on the current usage of the North Saskatchewan River.

Bell at al (1978) did not detect Salmonella in the pulp mill effluent entering the North Saskatchewan River but did detect numerous antibiotic resistant FC bacteria in the mill effluent and in the river. They also reported numerous isolations of single and multiple antibiotic resistant strains of Salmonella, particularly in the effluent plume downstream of the municipal sewage outfall on the south side of the river. They concluded that the origin of these potentially pathogenic species was likely the municipal sewage effluent discharged from Prince Albert. Because of the association of several of the Salmonella species with human infection, they expressed concern over reuse of the river water.

Although no attempt was made to determine the presence or characteristics of Salmonella in the river during the autumn 1983 surveys, the results of bacteriological monitoring of the municipal effluent (Table 3.2) and water in areas under its influence in the river (Figure 6, 9) suggests that the situation with respect to contributions of Salmonella to the river via undisinfected primary treatment plant effluent likely has not improved since the time of the Bell et al (1978) study.

Disinfection of the municipal sewage effluent and/or more advanced wastewater treatment would likely have an immediate and beneficial influence on the bacteriological quality of the North Saskatchewan River from Prince Albert to the confluence. More advanced wastewater treatment, such as the inclusion of secondary clarifiers in the sewage treatment facility in Prince Albert, would afford a long term means of enhancing the effectiveness of disinfection of the effluent. Since a chlorination contact chamber was included in the construction of this facility in 1972 disinfection of the primary effluent could be implemented immediately without extensive modification of the existing treatment plant. As a minimum operating requirement, disinfection should be implemented as soon as possible on a seasonal basis in order to improve the quality of the river water at least during the open-water periods.

Disinfection of the pulp mill effluent, however, as a means of reducing or eliminating the observed high FC populations may be neither practical nor desirable because of the potential for the formation of mutagenic substances resulting from chemical reactions with disinfectants such as chlorine (eg: Douglas et al 1980). On the basis of literature concerning the apparently common phenomenon of growth of FC in pulp mill wastewater treatment systems (eg: Environment Canada 1972, 1973; Caplenas et al 1981), the observation of only negligible levels of FS bacteria in the PAPCO effluent (Table 3.2) in the present study and the relatively small volume of sanitary wastes added to the system, it is very likely that the majority of FC in the PAPCO effluent were due to growth of enteric bacteria (eg: Klebsiella) in the wastewater system and not because of the addition of sanitary wastes. The calculated theoretical contribution of FC from the sanitary wastes (Section 3.1.3) to the FC levels observed in the final PAPCO effluent during the autumn 1983 surveys was less than 0.2 percent. This also supports the conclusion regarding the non-fecal origin of the FC in the final effluent.

Additional testing would be required to confirm the relative contribution of the sanitary wastes to the FC population in the pulp mill effluent. Testing for FS in the effluent would help to determine this since FS are normally present at high levels in sanitary wastewater (eg: Table 3.1). The use of alternative analytical procedures specific for E. coli (eg: Dufour et al 1981) or additional monitoring of the FC population in the effluent for the presence of E. coli using identification procedures on FC isolates (eg: Appendix 6) would provide further information in these regards.

If such analyses were to demonstrate that a significant portion of FC in the effluent were of direct fecal origin changes in the treatment afforded sanitary wastes at the pulp mill might then be required to provide a means of reducing the potential water quality implications associated with the discharge of this effluent to the river. Such changes, if required, might involve disinfection and/or separate treatment of the sanitary wastewater produced at the mill.

At present, however, the high observed levels of FC bacteria in the PAPCO effluent are of concern mostly with regard to water quality assessment of the river below transect R9 (Figure 9) since in this lower reach of the river they tend to obscure the definition of the mixing pattern of bacteria in the municipal sewage effluent plume, and prevent the determination of the FC population in the river that is attributable to the sewage effluent. In the future as well, the pulp mill effluent could have the effect of contributing to high observed levels of FC bacteria to the river downstream of the pulp mill effluent outfall, even after the implementation of disinfection of the municipal sewage effluent to reduce or eliminate fecal bacteria in that wastewater. This could result in erroneous conclusions being made with regard to the results of future water quality studies of the bacteriological characteristics of the receiving waterbody, particularly in downstream areas of the North Saskatchewan River or possibly in reservoirs on the Saskatchewan River where future use of the waters may have emphasis on contact recreation. Alternative analytical procedures specific for _E. coli_ and/or for enterococci of human fecal origin (eg: Levin, Fischer & Cabelli 1975) might provide a better means of assessing the bacteriological quality of the river in reaches impacted upon by the pulp mill effluent than is currently available with standard procedures for the FC and FS variables.

3.2.2 Dissolved Oxygen, Organics, and Nutrients

3.2.2.1 Dissolved Oxygen

In the autumn 1983 surveys, monitoring of dissolved oxygen concentrations, nitrogen, phosphorus, dissolved organic carbon (DOC), and biochemical oxygen demand (BOD) was conducted to determine the oxygen regime of the river and to examine the possible impacts of effluent sources on these variables. The following sections relate to this subject. Detailed water quality measurements pertaining to the above variables are recorded in Appendix 7.

Dissolved oxygen concentrations in a river are regulated to a great degree by contact of the water with the atmosphere, by altitude, by water temperature which directly regulates the solubility of oxygen in water, by water velocity, by aquatic plant growths, and by the loadings of organic materials whose decomposition utilizes oxygen. Rapids, such as occur at transect R11 (Cole Rapids, 15 Km above the confluence) on the North Saskatchewan River, are also significant in their effects of reaerating water and in maintaining high dissolved oxygen levels in rivers.

Individual dissolved oxygen values provide information only about the absolute quantity of this element dissolved in water but do not give information about the degree of saturation of the water at the temperature occurring when the sample is obtained. For instance, an open water may contain an adequate quantity of oxygen for fish survival (eg: 5 mg/L) but if this quantity present is less than accounted for by solubility of oxygen at the recorded water temperature, there is an indication that some substance or process is utilizing oxygen at a rate exceeding its diffusion from the atmosphere or from photosynthesizing aquatic plants and algae. Such substances may be introduced to a river through effluent discharges or may occur due to naturally occurring high levels of labile organic matter.

In all rivers diurnal fluctuations of oxygen content are commonly observed. During periods of darkness when photosynthetic contributions of oxygen to the water ends, plant respiration and microbial activity may utilize oxygen at a rate faster than diffusion from the atmosphere can replace it. Under such conditions oxygen concentrations below expected saturation levels are frequently encountered in rivers. Reductions in oxygen content to levels below saturation are also frequently observed in rivers during daylight in areas directly influenced by high loads of organic material and nutrients associated with wastewater effluent discharges.

As indicated by a review of the historical water quality data pertaining to oxygen levels and percent saturation of oxygen in the North Saskatchewan River (Section 1.5) periodic oxygen deficiencies were recorded for locations on the river between Prince Albert and the confluence. In some locations, particularly the confluence area, almost total depletion of oxygen was noted (Appendix 2).

During the autumn 1983 surveys, all dissolved oxygen measurements made during daylight hours at river transect stations were well above the provincial water quality objective of 5.0 mg/L (Appendix 2). Generally, oxygen levels were near to saturation or above saturation at most sampling locations including the confluence. Only two relatively low values were noted and these involved the measurement of dissolved oxygen at a level of 6.6 mg/L (62% saturation) in the pulp mill effluent plume at transect R9 and a level of 9.0 mg/L (72% saturation) at R8 in the north half of the river (Table 3.5). There was no indication of significant oxygen consumption related to the sewage effluent plume at stations on the south side of the river at transect R6 or at transects further downstream of the sewage effluent outfall. There was only a slight trend towards reduced oxygen concentrations in the river below the two major effluent outfalls compared to oxygen levels in the river upstream of the city of Prince Albert. Therefore, on the basis of similar relatively high oxygen concentrations in the river reaches above and below the major effluent discharges, the impacts of the effluents could be concluded as being only minor and limited to localized areas immediately influenced by the effluent.

Time of travel related data which concerned the measurements of water quality variables in slugs of water moving downstream at a known velocity were determined for dissolved oxygen and percent saturation on several occasions during the two surveys. These results are shown in Table 3.5. In each instance where such measurements were made, there was little change in either dissolved oxygen content or percent saturation as the monitored slugs of water moved in a downstream direction and received effluents in their course of travel. The sewage and pulp mill effluents, therefore, did not appear to impact significantly on the oxygen regime of the river during the daylight hours when the autumn 1983 surveys were conducted.

Dissolved oxygen and temperature measurements were also recorded at hourly intervals for one-day periods in both surveys at the north and south shores of the river at Cecil Ferry (R10) using an automatic monitoring device.

The percent saturation dissolved oxygen levels were calcuated from data obtained from the device's chart recorder. Due to equipment malfunction during the first survey, only eleven hourly measurements for dissolved oxygen and temperature were obtained at the south shore of R10. Complete diurnal data, however, was obtained for the second survey. A summary of

TABLE 3.5

TIME OF TRAVEL QUALITY DATA
DISSOLVED OXYGEN - mg/L
(OXYGEN SATURATION - %)

Dates	Tran-sect	RB	10 m RB	.25 RB	.33 RB	.5 RB	.33 LB	.75RB	10 m LB	LB
Oct 17	R1			14.8(122)		15.0(123)		14.3(118)		
	R2	14.5(119)								
	R3							*15.2(128)	15.0(127)	
	R4		14.8(122)	14.9(119)		15.0(125)		15.1(127)		
	R5			15.4(138)		15.1(127)		15.2(128)		
Oct 18	R12	10.3(87)			14.2(113)	13.9(111)				
	R13	14.9								
Oct 31	R1			13.5(108)		13.1(108)		13.3(109)		
	R2	13.7(113)								
	R3							*13.4(110)	14.6(119)	
	R4		13.3(109)	14.4(118)		13.7(112)		13.3(109)		
	R5		13.9(112)	14.4(118)		14.0(112)		13.5(108)		
Nov 1	R12	12.5								
	R13	12.4								
Oct 18	R5			14.5(115)		14.0(111)		14.5(115)		
	R6		14.8(122)	14.5(116)		15.1(125)		14.3(118)		
	R7		14.9(121)	16.3(134)		15.2(126)		15.1(124)		
	R8		14.2(115)	14.3(116)		15.3(126)				
	R9		15.2(125)	14.4(118)		15.6(126)		14.4(115)	6.6(62)	
	R10				14.4(120)	15.3(127)	14.8(123)			
Oct 19	R5			14.9(117)		14.1(110)		14.6(116)		
	R7		15.4(120)	13.9(109)		14.4(113)				
	R8									14.9(116)
Oct 19	R9			14.8(118)		14.5(116)		14.1(113)	15.2(122)	
	R10				15.3(124)	14.5(117)	13.6(110)			
	R11			15.1		15.2		14.9		
Nov 1	R5		12.3	12.6		12.4		12.9		
	R6		11.9(95)	12.2(98)		12.8(103)		12.1(97)		
	R7		12.1(97)	12.4(100)		12.7(102)		12.2(98)	12.5(100)	
	R8		11.8(95)	12.3(99)		12.3(99)		9.0(72)	12.2(98)	12.6(101)
	R9		12.3(98)	12.8(103)		12.4(99)		12.7(102)	10.4(91)	
	R10				13.0(104)	12.8(104)	11.9(100)		12.7(109)	
Nov 2	R5		12.5	13.9(110)		12.9(106)		12.9(102)		
	R7		15.0(118)	13.5(107)		14.8(117)		13.4(106)	13.0(103)	
	R8		13.4(106)	13.7(109)		13.8(109)		13.9(110)	12.9(102)	13.2(104)
Nov 2	R9		11.2	13.5		12.2		13.0	13.0(99)	
	R10				13.5	13.5	12.8		12.9	
	R11			13.2		13.5		13.8	13.4	

RB = Right (South) Bank; LB = Left (North) Bank

* 100 m LB

these data are recorded in Appendix 8. Dissolved oxygen and percent saturation values for each day of monitoring have been plotted in Figure 8.

During the two surveys, dissolved oxygen concentrations in the river between R1 and R13 ranged from 11.0 to 15.0 mg/L. These values are all well above the provincial surface water quality objective for this variable. There were only moderate decreases in dissolved oxygen levels accompanying the onset of darkness (1700 - 1800 hours) associated with sunset times during the two surveys. Generally, dissolved oxygen levels were restored to near maximum values several hours after sunrise on each day of the surveys for which complete data were obtained. These observations and the supersaturated conditions suggest that significant photosynthetic activity occurred in the river during daylight hours during the autumn study.

Only partial data is available for the October 17, 18, 1983, monitoring of the river at the south shore but during the period for which data was obtained (1600 h October 17 to 0200 October 18, 1983) dissolved oxygen was present at levels above saturation. At this location during the second survey, percent saturation values ranged from 87 to 98 percent with minimum values recorded during hours of darkness.

On the north shore of transect R10, dissolved oxygen levels ranged from 11.4 to 12.7 mg/L with corresponding percent saturation values ranging from 90 to 100 percent during the period 1800 h October 18 to 1400 h October 19, 1983. In the second survey, slightly lower levels of oxygen and percent saturation were recorded for this site with dissolved oxygen levels ranging from 11.2 to 12.0 mg/L with percent saturation ranging from 87 to 97 percent.

These results suggest that in autumn 1983, dissolved oxygen during daylight hours was present at or near saturation levels with only moderate decreases occurring due to increased oxygen consumption (microbial and plant respiration) during darkness hours at transect R10. Lower minimum dissolved oxygen and percent saturation values have been recorded for the north and south portions of the river at this transect during autumn seasons in the past

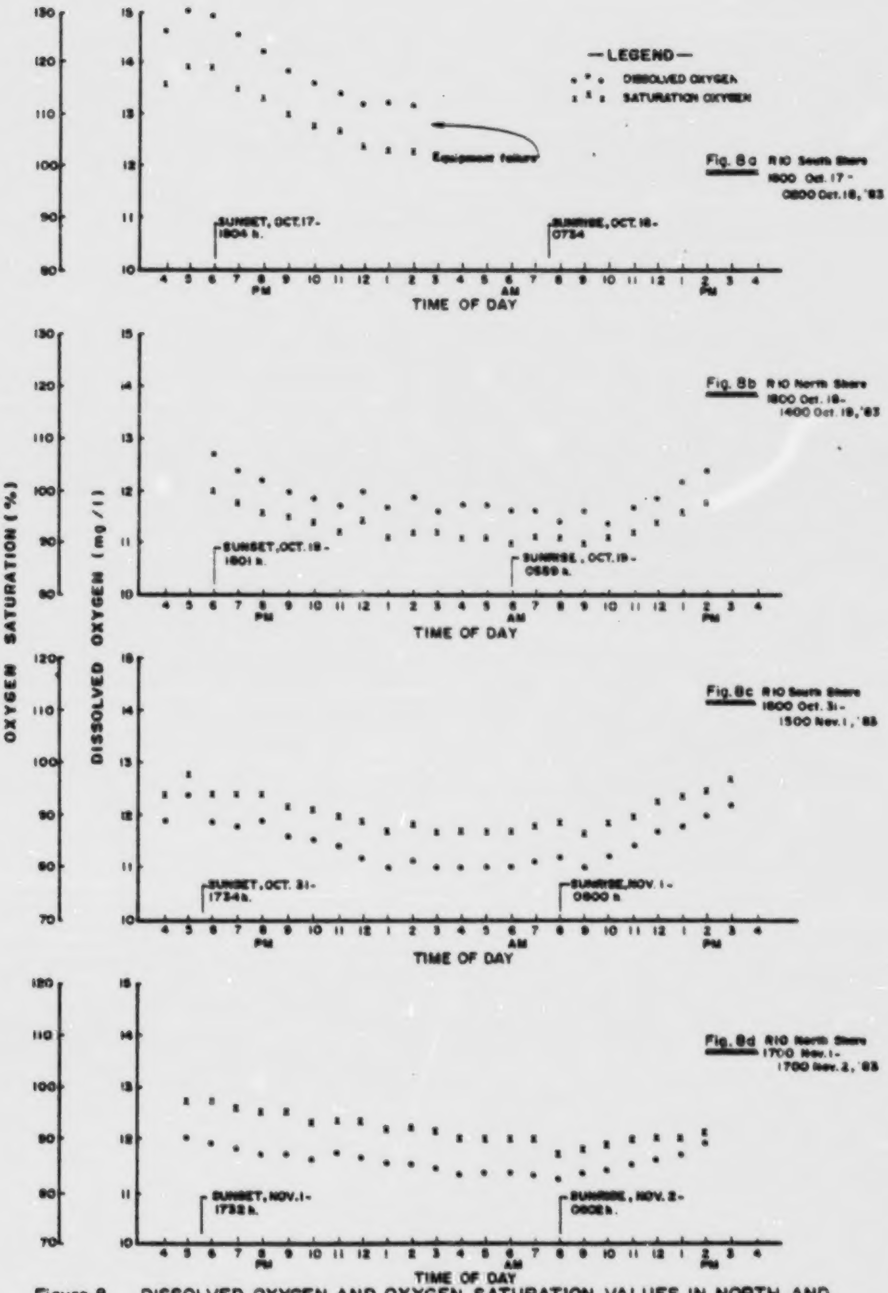


Fig. 8a R10 South Shore 1800 Oct. 17 - 0800 Oct. 18, '83

Fig. 8b R10 North Shore 1800 Oct. 18 - 1400 Oct. 19, '83

Fig. 8c R10 South Shore 1800 Oct. 31 - 1500 Nov. 1, '83

Fig. 8d R10 North Shore 1700 Nov. 1 - 1700 Nov. 2, '83

Figure-8 DISSOLVED OXYGEN AND OXYGEN SATURATION VALUES IN NORTH AND SOUTH SHORE LOCATIONS AT TRANSECT R10 (CECIL FERRY CROSSING) DURING OCTOBER AND NOVEMBER, 1983 SURVEYS.

(Appendix 2), but the historical data may be biased by data from periods when less effective treatment was given to the pulp mill and sewage effluents with respect to reduction of organic materials. The historical data may also be biased by dissolved oxygen and percent saturation values determined during periods of ice cover on the river in late autumn. During the present study, however, no significant impacts on the dissolved oxygen regime at transect R10 could be attributed to the discharges of sewage and pulp mill effluent to the river.

3.2.2.2 Organics

Of the variables which might relate most closely to oxygen consumption in the river, had such been observed, there seemed to be little impact of either the sewage or pulp mill effluents in increasing the BOD or DOC of the river water.

One exception to this general observation was the measurement of DOC at levels of 82 mg/L, and of 16 mg/L and 21 mg/L at transect R9 in the effluent plume (Appendix 7) in the first and second surveys, respectively. This was the only transect at which significant differences were noted across the river with respect to influence of the effluents on DOC levels in the water.

It was observed that BOD measurements, and to a lesser extent DOC values, were generally higher for samples obtained in the October 1983 survey compared to the second survey results. These differences may reflect natural fluctuations in levels of these variables in the river. Throughout both surveys, however, there was generally no indication of an appreciable influence on the river with regard to these variables. Upstream water quality apparently had a greater influence in determining the BOD and DOC levels in downstream areas than did the effluents.

The time of travel related data pertaining to BOD and DOC are shown in Table 3.6. These data do not indicate any marked increases in BOD or DOC, with the above noted exceptions, on the river water as it received effluent discharges. In several instances in some of the slugs of water examined, such as the column of water 10 m from the south shore (10 m RB) on November 1, 1983 between R5 and R10, higher BOD levels were recorded for upstream stations (eg: R5) than at the downstream station (eg: R10) below a major effluent outfall, indicating that reductions in BOD occurred within a relatively short distance and time interval. In general, however, no such reductions in BOD or DOC were noted for the other slugs of water examined. It does not appear, therefore, that the sewage or pulp mill effluents impacted significantly on the levels of oxygen-consuming organic constituents measured by BOD and DOC determinations. Perhaps only within the effluent plume of the pulp mill immediately downstream of the discharge point was a significant impact apparent. These findings agree with respect to observations made above with regard to the observation that these effluents had little impact on the daytime autumnal oxygen regime of the river. In general, the upstream water quality seemed to have more influence in determining the observed BOD and DOC levels in downstream areas than did any of the effluent discharges during both of the autumn 1983 surveys.

No apparent influence on the river water quality with respect to BOD and DOC loadings from the

TABLE 3.6

TIME OF TRAVEL QUALITY DATA
BIOCHEMICAL OXYGEN DEMAND - mg/L
(DISSOLVED ORGANIC CARBON - mg/L)

Dates	Tran-sect	RB	10 m RB	.25 RB	.33 RB	.5 RB	.33 LB	.75RB	10 m LB	LB
Oct 17	R1			4.4(3.6)		4.8(3.6)		4.6(4.0)		
	R2	4.6(3.8)						*5.0(4.3)	4.8(4.0)	
	R4		5.0(4.5)	5.0(4.0		5.0(4.4		5.0(4.6)		
	R5			5.5(4.0		4.2(5.0)		4.6(3.7)		
Oct 18	R12	6.0(6)			5.5(5)	6.0(7)				
Oct 18	R13	6.0(7)								
Oct 31	R1			1.6(3)		1.6(3)		1.4(3)		
	R2	1.4(3)								
	R3							*1.2(3)	1.6(3)	
	R4		1.8(3)	1.8(3)		1.6(3)		1.2(3)		
	R5		1.8(3)	2.0(3)		1.4(3)		1.6(3)		
Nov 1	R12	2.0(5)								
Nov 1	R13	2.6(5)								
Oct 18	R5			5.0(5)		4.6(5)		4.4(6)		
	R6		6.0(4)	5.0(4)		5.0(4)		4.6(5)		
	R7		4.8(5)	5.0(4)		4.8(5)		4.8(4)		
	R8		4.8(5)	5.0(5)		5.0(5)				4.6(14)
	R9		4.0(4)	4.8(4)		4.6(5)		4.8(4)	1.0(82)	
	R10				5.0(5)	4.8(5)	7.0(8)			
Oct 19	R5			4.2(8)		4.0(7)		4.0(5)		
	R7		4.6(5)	4.8(5)		4.8(5)		4.8(5)		
	R8		4.4(5)	5.0(5)		5.0(5)				4.6(5)
Oct 19	R9		4.0(6)	5.0(5)		5.5(5)		5.0(5)	4.8(7)	
	R10				3.2(6)	5.0(7)	6.0(11)			
	R11			6.0(10)		6.0(8)		5.0(7)		
Nov 1	R5		4.8(5)	4.0(4)		1.2(3)		1.2(3)		
	R6		3.0(4)	1.4(3)		1.4(3)		2.6(3)		
	R7		2.0(4)	2.0(3)		1.4(3)		1.6(3)	1.6(3)	
	R8		2.0(3)	1.8(4)		1.8(3)		1.6(3)	1.4(4)	2.0(3)
	R9		1.8(3)	1.6(3)		1.8(3)		1.8(4)	4.0(16)	
	R10				2.0(3)	2.0(4)	3.0(10)		3.6(11)	
Nov 2	R5		1.2(3)	1.4(3)		1.4(3)		1.2(3)		
	R7		2.0(3)	2.2(3)		2.2(3)		1.4(3)	2.0(3)	
	R8		1.6(3)	1.8(3)		1.6(3)		1.6(3)	1.2(3)	2.6(3)
Nov 2	R9		1.8(4)	1.6(3)		1.2(3)		1.2(3)	5.0(21)	
	R10				2.2(4)	2.2(4)	4.8(9)		3.0(10)	
	R11			2.8(8)		2.0(6)		2.0(5)	5.0(9)	

RB = Right (South Bank); LB = Left (North) Bank

*100 m LB

storm sewers in Prince Albert was observed. Even though high levels of BOD and DOC were associated with the storm sewer at 6th Avenue West (Appendix 3), the rate of discharge to the river was probably insufficient to cause an appreciable impact on the river water quality.

3.2.2.3 Nutrients

Nitrogen and phosphorus are important as major nutrients influencing plant and algal growth in aquatic systems. When supplies of nitrogen and phosphorus are abundant, high levels of plant and algae growth can result. Through decomposition of this resultant botanical material and through dark respiration by plants and algae during night periods, increased consumption of oxygen can result and deplete oxygen in the water column.

Increased plant and algal growth can also interfere with water uses related to fisheries, navigation, recreation, and water supply. Municipal and industrial wastewaters can contribute substantial quantities of these nutrients to a river through effluent discharges. In the present study, the daily contributions of nitrogen (TKN plus NO_3-N) and phosphorus (total) from the Prince Albert sewage treatment plant ranged from 653 - 729 kg/day total nitrogen and 105 - 145 kg/day total phosphorus (Table 3.1). Similar daily loadings of nitrogen were added to the river by discharges of the pulp mill effluent. The pulp mill effluent loading of total phosphorus ranged from 70-77 kg/day during the two 1983 surveys (Table 3.2).

Both total nitrogen (TKN) and total phosphorus concentrations in the river water samples were found to be within the ranges reported for historical data (Appendix 2) and were consistantly higher in the first survey than in the second survey in 1983 (Appendix 7). The differences in levels of these nutrient variables between the two surveys may simply reflect natural fluctuations of nitrogen and phosphorus levels in the river.

During the first survey, most TKN values were in the range of 0.8 - 1.3 mg/L although slightly higher values were observed at some transect stations. The maximum TKN value (3.0 mg/L) observed in the first survey was in a sample obtained from a station at transect R9 within the pulp mill effluent plume (10 m LB). Total phosphorus concentrations generally ranged from 0.12 to 0.19 mg/L although slightly higher values were recorded at some stations. At R9 within the pulp mill effluent plume, the maximum phosphorus concentration was observed to be 0.3 mg/L on one occasion only (Appendix 7). In general, however, only a slight change in the river water quality with respect to these nutrients as a consequence of the discharge of the sewage or pulp mill effluents was observed.

During the second survey, TKN values in the river samples generally ranged from 0.4 to 1.0 mg/L with a maximum level (1.7 mg/L) being observed at transect R10 (20.1 Km below the sewage effluent outfall) towards the south shore of the river. Total phosphorus values in the survey were generally within the range of 0.01 to 0.12 mg/L with maximum values of 0.16 mg/L being observed at transect R5 on one day only. TKN and total phosphorus levels in the river at transects upstream (eg: R1 - R5) of the two major effluents discharges (sewage and pulp mill) generally were lower than values recorded at downstream stations in both surveys. The difference was only slight with respect to TKN values, however. These findings suggest only a slight impact of the major effluents on the river during the two surveys with respect to TKN and total phosphorus levels in the river.

With these differences of TKN and total phosphorus in mind, it is worthy to note that at most stations, including those upstream of the major effluent discharge points, TKN levels were near to or slightly above the provincial surface water quality objective for TKN (1.0 mg/L). The values observed for total phosphorus at most sampling stations were also generally at or above the surface water quality objective for this variable (0.05 mg/L). Such observations are commonly observed in surface waters in the southern half of the province owing to naturally high levels of nutrients in waters.

The time of travel related data regarding TKN and total phosphorus levels in the river are presented in Table 3.7. These data indicate only slight increases in TKN levels associated with the effluent discharges on the south (sewage) and north (pulp mill) shores of the river and only for relatively short distances downstream of the discharge points. There was considerable variability in TKN and total phosphorus values at all stations during the two surveys so that occasionally higher TKN and total phosphorus values were observed upstream of the effluent discharge points than below (eg: October 19, 1983, .25 RB; November 1, 1983, 10 m RB). The impacts of effluent loadings of TKN and total phosphorus may therefore be of relative significance only when upstream levels of nitrogen and phosphorus are relatively low, as has been the trend during past fall seasons (eg: Appendix 2), and/or in areas immediately below the discharge points. In the present study, the upstream water quality apparently had a more significant impact on downstream nutrient (N,P) concentrations than did the loadings of nitrogen and phosphorus associated with the major effluent discharges.

3.2.3 Inorganic Variables

3.2.3.1 pH

The pH of water provides an indication of the balance between acids and bases and is a measure

TABLE 3.7

TIME OF TRAVEL QUALITY DATA
TOTAL KJELDAHL NITROGEN - mg/L
(TOTAL PHOSPHORUS - mg/L)

Dates	Tran-sect	RB	10 m RB	.25 RB	.33 RB	.5 RB	.33 LB	.75RB	10 m LB	LB
Oct 17	R1			0.9(0.14)		0.9(0.14)		0.9(0.14)		
	R2	1.0(0.15)								
	R3							*1.0(0.12)	1.1(0.14)	
	R4		0.9(0.16)	1.1(0.13)		0.8(0.13)		0.9(0.12)		
	R5			0.8(0.14)		1.0(0.12)		0.7(0.13)		
Oct 18	R12	1.1(0.13)			1.0(0.12)	1.1(0.15)				
	R13	1.0(0.12)								
Oct 31	R1			0.5(0.06)		0.5(0.06)		0.4(0.06)		
	R2	0.6(0.08)								
	R3							*0.5(0.07)	0.4(0.05)	
	R4		0.8(0.09)	0.5(0.10)		0.5(0.05)		0.5(0.07)		
	R5		0.8(0.09)	0.7(0.08)		0.8(0.08)		0.7(0.08)		
Nov 1	R12	0.6(0.08)								
	R13	1.0(0.15)								
Nov 1	R5		1.0(0.16)	0.8(0.16)		0.4(0.06)		0.5(0.10)		
	R6		0.9(0.11)	0.6(0.06)		0.7(0.06)		0.8(0.10)		
	R7		0.6(0.08)	0.7(0.08)		0.5(0.08)		0.5(0.06)	0.8(0.05)	
	R8		0.7(0.07)	0.6(0.07)		0.6(0.07)		0.9(0.08)	0.6(0.04)	0.7(0.05)
	R9		0.6(0.07)	0.6(0.06)		1.0(0.13)		0.6(0.06)	0.8(0.09)	
	R10				0.7(0.11)	0.6(0.06)	0.7(0.08)		0.7(0.08)	
Nov 2	R5		0.7(0.07)	0.5(0.05)		1.2(0.08)		0.5(0.05)		
	R7		0.6(0.07)	0.7(0.09)		1.0(0.06)		0.8(0.07)	0.7(0.07)	
	R8		0.9(0.12)	0.8(0.07)		0.8(0.07)		0.7(0.06)	1.0(0.07)	0.7(0.07)
Nov 2	R9		0.7(0.08)	1.3(0.07)		1.0(0.07)		0.9(0.08)	1.0(0.08)	
	R10				1.7(0.12)	0.6(0.06)	1.0(0.06)		1.0(0.14)	
	R11			0.7(0.08)		0.9(0.07)		0.7(0.08)	1.0(0.08)	
Oct 18	R5			0.8(0.15)		1.0(0.13)		0.8(0.12)		
	R6		1.3(0.20)	0.8(0.13)		1.3(0.13)		1.2(0.13)		
	R7		0.9(0.13)	0.9(0.16)		1.2(0.13)		1.3(0.13)		
	R8		0.9(0.15)	0.9(0.14)		0.9(0.14)				1.0(0.14)
	R9		0.9(0.14)	1.1(0.15)		0.9(0.13)		1.0(0.14)	3.0(0.3)	
	R10				0.9(0.15)	1.0(0.14)	1.1(0.14)			
Oct 19	R5			1.4(0.19)		1.0(0.15)		0.9(0.13)		
	R7		1.2(0.17)	1.3(0.14)		1.0(0.15)		1.0(0.15)		
	R8		1.0(0.16)	0.9(0.14)		0.9(0.13)				1.1(0.13)
Oct 19	R9		1.0(0.19)	1.8(0.19)		0.9(0.14)		0.9(0.16)	1.2(0.17)	
	R10				1.0(0.15)	1.0(0.17)	1.2(0.14)			
	R11			1.1(0.15)		1.1(0.15)		1.1(0.13)		

RB = Right (South) Bank; LB = Lef (North) Bank

*100 m LB

of the hydrogen ion concentration in solution. During the two 1983 surveys, field measurements of pH at transect stations ranged from pH 8.2 to 9.2 at most stations (Appendix 7). The laboratory measurements performed on water samples were generally lower in value by about 0.1 - 0.5 pH units, likely as a result of the changes which occur in samples between the time of their collection and laboratory analyses. A minimum value (pH 8.1) for field pH measurements was recorded at transect R9 within the pulp mill effluent plume on one occasion only. The field and lab pH values for river samples from the first survey were generally higher (range 8.2 - 9.2, field) and more variable than those recorded during the second survey (range 8.2 - 8.7, field). These differences likely reflect natural fluctuations which occur in all surface waters.

There were no apparent impacts on the pH of the river water due to discharge of sewage or pulp mill effluents except for very minor decreases in pH immediately below the pulp mill discharge at R9 within the effluent plume. The river water is well buffered (alkalinity generally exceeds 150 mg/L $CaCO_3$) and therefore readily dilutes and neutralizes the additional hydrogen ions contributed in the effluents at lower pH values than the river (Tables 3.1, 3.2). There were no instances in either of the two surveys where the pH of the river water was altered due to effluent discharge by more than 0.5 pH units, the maximum change over background pH levels designated in existing surface water quality objectives. In fact the observed pH levels of the river generally were near or above the upper limit of the desirable range of pH levels (6.5 to 8.5) in the current provincial surface water quality objectives. Such relatively high pH values are typical of surface waters flowing through the geological formation of the southern half of Saskatchewan and other prairie provinces.

3.2.3.2 Alkalinity

Alkalinity is a measure of a water's capacity to neutralize acid. It is expressed as an equivalent of calcium carbonate. During the autumn surveys, there was a tendency for higher alkalinity levels occurring during the first survey. Alkalinity values were generally in the range of 151 - 160 mg/L as $CaCO_3$ with individual samples being much higher under the apparent influence of the pulp mill effluent at R9 (10 m LB) where values of 190 - 376 mg/L were observed.

In the second survey, alkalinity values generally were within the range of 140 - 150 mg/L with only one slightly more elevated level (160 mg/L) detected very near the north shore of the river at R9 within or at the edge of the pulp mill effluent plume. The differences in alkalinity values observed in the river between the two surveys may reflect the natural variability in levels of substances (eg: $CaCO_3$) which contribute to the acid-neutralizing capacity of the water at different times. There was a tendency, however, for a very slight increase in alkalinity towards the downstream stations during both surveys. The effluents, therefore, had little apparent impact on the alkalinity of the river except perhaps in the immediate pulp mill outfall area. In general, upstream water quality had a more significant impact on the alkalinity of the water in downstream areas than did the major effluent discharges.

3.2.3.3 Chloride

Chloride determinations provide a means of determining the relative dispersion of effluents in a river and are particularly useful for observing the mixing characteristics of effluent in a river when significant quantities of this element are added to a river. As shown in Table 3.1 and 3.2, the ranges of chloride observed in the municipal sewage and pulp mill effluents were 126 - 292 mg/L and 560 - 670 mg/L, respectively. There was a general tendency for lower levels of chloride to be detected at nearly all river sampling locations during the second survey. In both surveys the flow characteristics of the river were similar (Figure 1) and the observed chloride levels were within the range of values recorded for the river previously (Appendix 2) so the differences between the results of the two surveys may reflect natural variation in chloride levels at different times. There was also a tendency in both surveys for slightly increased chloride levels in river stations downstream of Prince Albert and the major effluent discharge points, and this may reflect only a minor influence of the effluent and stormwater discharges on the chloride concentration in the river.

In the first survey, chloride levels at transects R1 - R5 ranged from 6 - 22 mg/L and from 9 - 34 mg/L at transects R6 to R13. In the second survey, the chloride levels at these same transect points ranged generally from 2 - 8 mg/L and 4 - 20 mg/L respectively. A pair of higher individual values for chloride were recorded as 30 and 46 mg/L during the second survey in the pulp mill effluent plume at transect R9 (Appendix 7). A single high value of 250 mg/L was recorded for chloride at the same R9 location in the first survey. This result may indicate that subsequent sampling during the second survey may have been on the outside fringe of the effluent plume and not directly within its path where maximum levels of effluent constituents would be expected.

The general increase in chloride in a downstream direction may be attributable to contribution of chloride from the major effluents and to minor contributions from the storm sewers in Prince Albert (Appendix 3). In terms of total loadings of chloride, the major source of this element added to the river in the Prince Albert area was the effluent discharged from the pulp mill (Table 3.2). The loadings of chloride associated with this effluent were of less significance in determining chloride levels in the water at downstream locations than was the quality of water flowing from the upper river reach.

The time of travel related data pertaining to chloride levels in the river are presented in Table 3.8. These data do not provide a clear indication of the direct sources of chloride being introduced to the south side of the river. However, they do show that maximum levels of chloride occurred on the north side of the river nearest the pulp mill discharge near transect R9. The decrease in chloride levels from the high values at R9 near the north shore to moderate levels observed across transects at downstream locations (R10) is most likely attributable to dilution of the effluent as it mixed laterally and longitudinally with the river water. The time of travel data pertaining to the November 1, 1983, sampling suggests that lateral mixing of chloride associated with the pulp mill effluent was not yet complete by the time the slug of water under study reached the R10 transect at Cecil Ferry. This is supported by visual observations of the colour of the river water at R10 which indicated that the brown-coloured pulp mill effluent had not dispersed across the width of the river by the time the water slug had reached this transect. Water on the south side of the river at R10 was not brown coloured.

3.2.3.4 Conductivity

Specific conductance or conductivity provides a rapid estimate of the total dissolved solids concentation of water. It measures the capacity of water samples to conduct electric current and is therefore a means of measuring the concentration of the major ions which represent most of the dissolved solids present in the water. As was generally observed for BOD, DOC, nitrogen, phosphorus, pH, alkalinity and chloride, there was a tendency for slightly lower conductivity levels at the river stations during the second survey. Since flows in the river were similar during both surveys (Figure 1) the reasons for differences in the results for these variables between the two surveys cannot be readily explained, but may relate to natural variability in levels of these constituents at different times. Conductivity measurements made on river samples during the fall 1983 study were all within the range of values recorded for the river in the past (Appendix 2).

Conductivity values generally ranged from 380 - 424 uS/cm and from 358 - 390 uS/cm in the first and second surveys, respectively. Higher values for conductivity were observed during the first survey at R9, within the pulp mill effluent plums (1,046 uS/cm) and at R11 (.33 LB) where conductivity values ranged from 463 - 465 uS/cm. Similar levels (443 - 445 uS/cm) were also observed at R11 at the station one-quarter the river width from the north shore.

In the second survey, three higher values for conductivity (400 - 430 uS/cm) were observed at the shoreline sampling site at R8, near the water intake for the pulp mill (Appendix 7). These elevated conductivity values may relate to ground water infiltration to the river near the sampling site. As noted for the first survey, the maximum value for conductivity was obtained at R9 (10 m LB) during the second survey. Values of 434 - 444 uS/cm were recorded for conductivity at R10 in the northern third of the river. The relatively higher levels of conductivity for these locations compared to the remainder of the river may be attributable to the impact of pulp mill effluent and to ground water infiltration along the north shore. Several springs were noted to emerge either from tiles or natural outlets near the base of the north bank of the river near the pulp mill water intake near R8. This observation supports the likelihood of ground water infiltration to the river in this area.

In both surveys, there was a tendency for higher conductivity values with respect to river water samples obtained nearest the northern shore of the river from transects R8 to R11.

The time of travel related data concerning conductivity measurements on river samples are shown in Table 3.8. These data do not provide any evidence of apparent increases in conductivity of the river water due to discharges of municipal sewage effluent near Prince Albert. However, as already indicated, these data suggest significant increases in conductivity of the river water along the north

TABLE 3.8

TIME OF TRAVEL QUALITY DATA
CHLORIDE - mg/L
(CONDUCTANCE - uS/cm)

Dates	Transect	RB	10 m RB	.25 RB	.33 RB	.5 RB	.33 LB	.75RB	10 m LB	LB
Oct 17	R1			10(409)		14(416)		10(421)		
	R2	8(411)								
	R3							12(413)	8(420)	
	R4		10(404)	8(410)		8(400)		12(403)		
	R5			10(412)		22(424)		8(410)		
Oct 18	R12	10(428)			18(410)	16(410)				
	R13	18(426)								
Oct 31	R1			4(372)		2(374)		4(382)		
	R2	4(381)								
	R3							4(375)	4(382)	
	R4		2(379)	4(376)		2(376)		6(379)		
	R5		4(378)	4(377)		4(372)		6(372)		
Nov 1	R12	8(397)								
	R13	10(410)								
Oct 18	R5			10(415)		6(424)		10(400)		
	R6		12(412)	12(398)		10(402)		10(409)		
	R7		10(406)	14(409)		12(380)		14(390)		
	R8		12(400)	12(400)		16(402)				10(410)
	R9		8(400)	10(399)		8(400)		8(400)	250(1040)	
	R10				10(402)	8(404)	20(450)			
Oct 19	R5			12(394)		10(392)		20(391)		
	R7		10(397)	10(395)		12(395)		10(402)		
	R8		12(399)	10(396)		10(402)				10(402)
	R9		12(398)	8(394)		8(394)		12(394)	16(422)	
	R10				12(395)	16(411)	26(460)			
	R11			20(443)		16(421)		14(408)		
Nov 1	R5		8(385)	4(375)		4(372)		4(372)		
	R6		6(377)	4(366)		4(369)		4(377)		
	R7		6(375)	4(358)		4(371)		4(367)	4(370)	
	R8		4(371)	4(370)		4(371)		4(374)	4(365)	4(377)
	R9		6(369)	4(370)		4(374)		6(370)	30(485)	
	R10				8(380)	6(377)	18(438)		20(444)	
Nov 2	R5		4(373)	2(372)		4(374)		4(372)		
	R7		4(377)	4(375)		4(372)		4(374)	4(376)	
	R8		8(383)	4(380)		4(375)		4(373)	4(385)	4(425)
	R9		6(390)	6(387)		2(384)		4(385)	46(575)	
	R10				4(377)	6(436)	18(440)		16(434)	
	R11			12(415)		6(391)		4(379)	4(427)	

RB = Right(South) Bank; LB = Left(North) Bank

* 100 m LB

shore of the river as a consequence of pulp mill effluent discharges and possible ground water infiltration from transect R9 to R11. Data pertaining to north shore locations downstream of R11 are lacking so the extent of the pulp mill effluent impact with regard to elevated conductivity and associated dissolved solids concentrations cannot be determined at this time for the downstream north shore locations. The conductivity of water entering the North Saskatchewan River from the Garden River just upstream of transect R11 is also unknown.

These results do not indicate a significant impact on conductivity of the river due to municipal sewage effluents and storm sewer discharges. Moderate impacts of this kind may be attributed to pulp mill effluent discharge especially in the areas of the north side of the river immediately below the pulp mill effluent outfall. Contributions of ions by groundwater and entry of the Garden River cannot be assessed at this time.

3.2.4 Colour

Colour (apparent colour) is a measure of the dissolved and suspended colouring materials present in a water. The colour may be attributable to the presence of organic and inorganic substances. Because of the inherent brown colour of the pulp mill effluent discharged to the North Saskatchewan River, the measurement of colour provides an estimation of the mixing characteristics of the effluent discharged to the North Saskatchewan River. Colour also provided a means of visually determining the location of the pulp mill effluent plume at least between transect R9 and R10, during the field work.

Colour values outside of the areas immediately influenced by the pulp mill effluent plume were relatively low and ranged from 2 to 16 units at most sites on the river where colour samples were collected (Appendix 7). During the first survey, a colour value of 1,100 units was recorded for the R9 transect station located within the effluent plume (10 m LB). In subsequent sampling during the first survey, the 10 m LB station may not have been directly in the plume and much lower colour values were recorded. Colour values in excess of 10 units were generally restricted to portions of the north side of the river between R9 and R11 although values slightly over 10 units were noted at R12 and R13 which may be attributable to dispersion of the effluent plume to the south side of the river at these locations.

In the second survey, the highest colour values were again associated with the northern R9 (10 m LB) location where values of 78 and 109 units were observed. Values in the ranges of 30 - 38 and 36 - 41 units were also observed in the second survey at the north side of transect R10 (10 m LB) and at .33 LB of R10, respectively. Farther downstream at transect R11, colour values of 24 and 28 units were observed on one occasion at the .25 LB and 10 m LB stations.

These results indicate that the impacts of effluent discharge on the apparent colour of the North Saskatchewan River are related only to that of the pulp mill. Visually, the river became coloured across its width due to lateral mixing of the effluent with the river water by the time the effluent reached R11.

The time of travel data pertaining to apparent colour are shown in Table 3.9. These data show evidence of lateral mixing of the pulp mill effluent having occurred as the slugs of water being examined (October 19, November 2, 1982 data) reached transect R11. The mixing, however, did not appear to be complete since the higher values for colour remained in association with stations nearest the north shore of transects R9 - R11. Data pertaining to R13 at the river confluence are limited to a few values for the south

TABLE 3.9

TIME OF TRAVEL QUALITY DATA
COLOUR - ALPHA UNITS

Dates	Tran- sect	RB	10 m RB	.25 RB	.33 RB	.5 RB	.33 LB	.75RB	10 m LB	LB
Oct 18	R8		5	5		5				6
	R9		5	5		5		5	1100	
	R10				6		36			
Oct 19	R9		5	5		5		5	17	
	R10				5	15	35			
	R11			28		17		10		
Nov 1	R8			5		4		5	5	5
	R9		5	4		5		5	78	
	R10				5	11	38		41	
Nov 2	R9		5	5		5		5	109	
	R10				5	10	30		36	
	R11			24		12		7	28	

RB = Right(South)Bank; LB = Left(North) Bank shore of the river where two values of 13 units were recorded for colour in the two surveys. These results indicate that the pulp mill effluent does not increase the colour of the entire river by more than 30 units, the allowable increase in colour permitted in the surface water quality objectives for Saskatchewan. This water quality objective was apparently exceeded, however, along the north shore of the river at least between transects R9 and R11.

3.2.5 Trace Elements

Heavy metal and trace substances in water are of concern particularly with regard to the consumptive and irrigational uses of water, and to the aquatic biota and wildlife which utilize the river. These variables may occur naturally in a water body mostly in association with bottom sediments and substrates, with generally only minute quantities present in the water column. The addition of sewage and industrial effluents may contribute to increased levels of metals and trace substances in water, however. A summary of data pertaining to these variables determined at selected sampling sites (R5 - mid river and R12 off right bank) on October 18 and November 1, 1983, is presented in Appendix 9. These data concern total metal or substance quantities per litre of water and hence, they can be influenced greatly by the presence of suspended sediment materials which may contain significant amounts of the variables being determined.

In general the concentration of all variables listed in Appendix 9 were either less than detection limits or were less than existing surface water quality objectives. For instance only negligible or trace quantities of arsenic, beryllium, cadmium, cobalt, chromium, copper, cyanide, lead, molybdenum, nickel, selenium, silver, titanium, vanadium, wolfram, and zinc were detected. Other variables, such as barium, boron, manganese, and iron were present at levels generally well below the provincial surface water quality objectives for these variables. Only one value for iron, which might be attributable to iron associated with suspended sediments, was observed at the level of the surface water quality objective (0.3 mg/L). There was relatively little difference between the R5 and R12 data.

These results indicated that no apparent increases in concentration of these variables occurred in the river between R5 and R12 which might have been attributable to contributions of heavy metals and trace substances present in sewage or pulp mill effluents discharged to the river below R5. The loadings of these variables in the effluents (Appendices 4,5) were apparently diluted and assimilated by the river without apparent impact on the quality of the water at transect R12.

Additional water samples were collected at these and other transects in both surveys and analysed for total mercury content. These results have been tabled in Appendix 10. Of the 69 samples analysed for total mercury content, mercury was not detected in 36 samples and was present at or very near the detection limit of 0.00002 mg/L in an additional 29 samples. The current surface water quality objective for total mercury is 0.0001 mg/L. Mercury levels above this objective value were observed in only two river water samples obtained from transect R5 at the .25 RB and .5 RB stations. The mercury levels in these samples were 0.00018 and 0.00052 mg/L, respectively (Appendix 7). Although the sewage and pulp mill effluents did contain small amounts of mercury (Appendices 4,5), these data do not indicate any apparent relationship between the observed mercury levels in the river and effluent discharges between the observed mercury levels in the river and effluent discharges along the river. The two observed values above the surface water quality objective for mercury may have been due to the chance occurrence of mercury containing suspended sediment in the sample or to sampling or laboratory analytical variability.

3.2.6 Miscellaneous

Resin acids are a constituent of pulp mill effluents and are found also in the natural environment as a byproduct of woody plant tissue decomposition. They are of significance to fisheries in particular. Resin acid concentrations in the pulp mill effluent ranged from 0.28 to 0.80 mg/L during the autumn 1983 surveys (Appendix 5). No detectable levels of resin acids were observed in the river water either at transect R8, upstream of the pulp mill effluent discharge or at R12 (all values were less than 0.05 mg/L).

Sulphides and mercaptans were also detected in the pulp mill effluent at values within the respective ranges of 0.6 - 4.1 mg/L and 0.7 - 6.1 mg/L. In samples obtained from sites near the north shore of R8 and from the south shore of R12, these constituents were not present in detectable quantities (eg: sulphides less than 0.01 mg/L). These results suggest that during the autumn 1983 surveys the pulp mill effluent did not have a measurable influence on the quality of water at Cole Rapids (R12) with respect to resin acids, sulphides, and mercaptans.

Pentachlorophenol (PCP) was detected (65 ug/L) on one sampling occasion in the 8th Avenue East storm sewer effluent (Appendix 3). However, no PCP was detectable in the river either at an upstream location (R1) nor at three locations along transect R4 below this storm sewer. The small quantities of PCP in the storm water likely were sufficiently diluted through mixing with the river water to prevent its detection at the downstream locations.

A biocide sample was collected from the south shoreline of transect R12 (Cole Rapids) and analysed for twenty-five herbicides and pesticides at the National Water Research Institute laboratory in Burlington, Ontario. Twenty-two of these variables were undetectable in the water sample. Only trace quantities of 2,4D (0.00002 mg/L), alpha BHC (0.000009 mg/L), and lindane (0.000005 mg/L) were found in the sample, with all values being very near the detection limit for these variables. These substances are periodically observed at trace levels in surface waters in the prairie environment but at these levels, do not impair the quality of the water for use by humans, animals or aquatic life.

Another variable, which was not determined quantitatively during the autumn surveys, relates to odour. Objectionable odours in water may reduce the asthethic quality of the waterbody and add to treatment requirements if such water is intended for consumptive usage. Field staff recorded qualitative observations of moderate odours typical of the pulp mill effluent for all samples obtained within the pulp mill effluent plume between transect R9 (0.8 Km below the pulp mill outfall) and transect R13, at the confluence.

Current usage of the river in this reach is apparently limited to noncontact recreation and complaints about the odour of the water from canoeists have been received by Saskatchewan Environment in the past.

ACKNOWLEDGEMENTS

The field work involved in collection of data presented in this report was conducted by staff of Saskatchewan Environment, Water Pollution Control Branch. The report was drafted by K.P. Lautenschlager in consultation with R.A. McDonald of M.R.2 Consulting Engineers. The efforts of S.A. Ferris, R.H. Zitta and L.F. Kratt in handling and preparation of data tables for the report was greatly appreciated. The review comments of staff of the Water Pollution Control Branch were of much assistance in preparing the report in its final form.

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APPENDIX 1

NORTH SASKATCHEWAN RIVER

PRINCE ALBERT AREA LIST OF KNOWN WATER USERS AND EFFLUENT DISCHARGES

APPENDIX 1

NORTH SASKATCHEWAN RIVER

PRINCE ALBERT AREA - KNOWN MAJOR INTAKES AND DISCHARGES

Distance Above Confluence (km)	Bank*	Description	Size (mm)	Comments
62.3	R	Est of 6 Avenue West	530	Includes water treatment backwash
62.2	R	6 Avenue West	735	Could include some industrial wastewater.
	R	5 Avenue West	450	
	R	4 Avenue West	900	
	R	3 Avenue West	450	
	R	2 Avenue West	900	East side of Diefenbaker bridge.
	R	1 Avenue West	380	
	R	Central Avenue	450	
	R	1 Avenue East (2)	600 900	
	R	3 Avenue East	300	
	R	4 Avenue East	600	
59.8	R	6 Avenue East	1200	
	R	7 Avenue East	300	
59.2	R	8 Avenue East	1200	
	R	9 Avenue East	1200	
	R	11 Avenue East	680	
	R	12 Avenue East	450	
	R	13 Avenue East	900	

APPENDIX 1

NORTH SASKATCHEWAN RIVER

PRINCE ALBERT AREA - KNOWN MAJOR INTAKES AND DISCHARGES

Distance Above Confluence (km)	Bank*	Description	Size (mm)	Comments
57.5	R	15 Avenue East	900	
57.0	R	1 Street East	750	
56.8	L	Crop Irrigation intake.		Cereal/forage crop watering.
56.0	R	Storm Channel		2100 mm pipe to open channel.
65.2	R	Intake - Prince Albert Pententiary for tree nursery and root garden on north side of Bett's Is.		Irrigation
62.3	R	Intakes - City of Prince Albert Water Treatment Plant	900 760	New Intake installed in 1983, withdrawal near river bed level.
62.3	R	Outfall - (Storm Sewer) - Water Treatment Plant	530	Intermittent discharge - filter backwash, overflow, sedimentation tanks (filter backwash for May - Aug/83 ranged 212-710 m^3/d).
62.0	L	Outfall - 3 Ave. NW - septic tank effluent	300	Serves 30-40 residences in north PA, est. flow 60-65 m^3/d.
		City Storm Water		
62.2 to 61.4	L	Various ditch outfalls		Serves north PA.

APPENDIX 1

NORTH SASKATCHEWAN RIVER

PRINCE ALBERT AREA - KNOWN MAJOR INTAKES AND DISCHARGES

Distance Above Confluence (km)	Bank*	Description	Size (mm)	Comments
64.5	R	20 Avenue West	380	
	R	18 Avenue West	680	
	R	15 Avenue West	1350	
	R	12 Avenue West	680	
	R	9 Avenue West	600	
62.6	R	8 Avenue West	600	
56.5	R	Outfall - City sanitary sewer emergency bypass	600	
56.3	R	Outfall - Prince Albert Pollution Control Centre	900	Approximately 9 m into river - at Discharge average 0.16-0.22 m^3/s.
51.2	R	Irrigation Intake		Cereal/forage crop watering.
48.8	R	Irrigation Intake		Cereal/forage crop watering.
48.4	L	Intake - Prince Albert Pulp Co.		Shore intake
46.5	L	Outfall - Prince Albert Pulp Co.	1350	Submerged diffuser - 43 m - north channel at Willow Island. Discharge approximately 1.08 m^3/s.

*R = Right; L = Left. Right and left bank designation corresponds respectively to the south and north shore of the river reach under study when viewed in a downstream easterly direction.

APPENDIX 2

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

APPENDIX 2

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

Variable - Measurements - Season		Station					
		Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Total Coliforms/100 mL (MPN) Years		1971-82	1970-82	1970-81	1970-81	1971-80	1971-79
Samples No.	A	165	116	161	163	76	94
	F	30	26	35	36	18	23
Range No.	A	10-28000	<10-75000	<23-930000	< 23-460000	90-750000	<23-460000
	F	10-15000	< 10-11000	<23-460000	40-460000	430-460000	210 -150000
Mean (geom)	A	242.0	606.1	8413.8	11321.4	11773.2	8449
	F	69.6	442.1	6581.1	9196.4	14198	6160
Median	A	230	430	21000	20000	11000	11000
	F	40	430	<11000	11000	11000	2400
Total Coliforms/100 mL (MF) Years		1978-82	1975-82	1975-82	1975-82	1978-82	1971-79
Samples No.	A	54	36	29	23	45	4
	F	10	10	10	6	10	0
Range	A	24->10,000	60->100,000	13-61,000	3000-94000	400-84000	<23-52000
	F	70-700	<100-7,700	200-61,000	4000->30000	2000-30000	--
Mean (geom)	A	244.7	684.1	3891.6	9829.3	6524.6	1835.4
	F	110.0	538.5	3674.6	8447.6	9745	--

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NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

Variable - Measurements - Season	Station					
	Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Median A	152	720	<5000	10000	8300	1000-9920
F	100	600	3100	8000	10000	--
Fecal Coliforms/100 mL (MPN) Years	1971-81	1970-80	1970-81	1970-81	1971-80	1971-79
Samples, No. A	108	112	157	161	73	92
F	29	25	35	36	17	23
Range A	<10->24000	<10-43000	10-930000	<23-430000	<23-240000	<23-460000
F	<10-4600	<10-4600	10-930000	<23-240000	<23-150000	<23-210000
Mean (geom) A	84.6	182.7	964.6	2623	2347.5	17.5
F	37.9	134.9	631.2	2305.2	1268	1008
Median A	40	205	750	2400	2400	930
F	<23	150	430	1615	2100	750
Fecal Coliforms/100 mL (MF) Years	1977-82	1975-82	1975-82	1975-82	1977-82	1971-79
Samples, No. A	55	37	25	24	43	4
F	12	11	10	6	11	0
Range A	<1->24000	<2->1000	<1-23000	40-16000	<10->1000	<23-4700
F	<1->24000	5-230	<10-23000	40->3000	<10->10000	--
Mean (geom) A	18.4	33.5	130.5	1319.2	544	367.4
F	13.4	19.3	146.6	16.0	494	--

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NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
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Variable - Measurements - Season		Station					
		Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Median	A	710	20	<100	1050	500	<100-1780
	F	>10	10	135	770	350	--
Fecal Streptococci/100mL (MF) Years		1970-83	1970-83	1970-83	1970-83	1970-83	1970-83
Samples, No.	A	66	43	38	24	50	4
	F	14	13	12	8	14	1
Range	A	<1-1200	<1->1000	1-2000	10-1600	4-1600	5-100
	F	<1-120	<10-150	<10-120	10-460	<10-300	10-10
Mean (geom)	A	17.4	18.8	18	106.2	78.6	26.5
	F	18.2	15.1	22.8	139.1	80	10
Median	A	10	10	10	110	95	10-<100
	F	10	<10	20	230	85	10
Specific Conductance us/cm							
Years		1971-82	1970-82	1970-82	1970-82	1971-82	1970-79
Samples No,	A	167	155	191	187	120	101
	F	42	37	42	42	29	23
Range	A	240-2000	190-1400	220-750	200-700	200-600	250-1000
	F	250-500	250-600	300-750	250-600	270-532	250-650
Mean	A	396	409	438	392	385	418
	F	363	376	429	381	371	387

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NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

Variable - Measurements - Season		Station					
		Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Median	A	390	400	450	400	400	400
	F	360	375	400	380	371	350
Chloride mg/L							
Years		1971-82	1970-82	1970-82	1970-82	1971-82	1971-79
Samples No,	A	165	155	189	187	120	120
	F	40	37	43	43	29	11
Range	A	<1-312	<2-150	<2-80	<2-84	<2-49	1.9-53
	F	<2-30	<2-68	2-80	<2-84	4-34	6-22
Mean	A	12	13	25	11	11	18
	F	10	11	28	12	11	12
Median	A	8	8	23	8	8	14
	F	8	8	26	8	8	10
Dissolved Oxygen mg/L							
Years		1971-82	1970-82	1970-82	1970-82	1971-82	1971-76
Samples, No.	A	155	163	187	177	112	95
	F	35	35	39	37	24	10
Range	A	3.5-16.4	2.1-18.0	2.3-16.3	1.5-16.1	1.0-16.9	0.09-20
	F	3.9-16.4	7.5-18.0	05.1-14.1	5.5-16.1	7.3-16.9	9.0-12.5
Mean	A	9.2	8.9	8.5	8.9	8.8	8.6
	F	11.4	12.1	10.7	11.9	12.1	10.3

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WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

Variable - Measurements - Season		Station					
		Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Median	A	8.7	8.7	8.2	8.8	8.6	8.9
	F	11.8	12.2	10.9	11.7	12.4	10.1
Percent Saturation % Years		1971-82	1970-82	1970-82	1970-82	1971-82	1971-79
Samples, No.	A	139	148	176	164	100	93
	F	32	33	37	35	23	11
Range	A	25-137	17-156	25-147	8-153	7-Q140.6	0.9-128
	F	37.9-120.0	80.6-129.0	Q50.9-109	8-117	78.1-Q140.6	92-105
Mean	A	83.7	81.6	77.2	80.7	84.4	76.8
	F	95.7	102.0	90.7	97.7	102.1	97.1
Median	A	90	88.9	82.0	91.0	93.0	92
	F	98.5	102.0	93	102	101	95
Biochemical Oxygen Demand mg/L Years		1971-82	1970-82	1970-82	1970-82	1971-82	1971-79
Samples, No.	A	156	148	178	178	113	98
	F	38	35	39	39	26	11
Range	A	0.2-40.0	0.1-15	0.6-42.0	0-13.5	0.4-7.0	0.6-27
	F	0.2-7	0.1-6.5	Q1.0-35	0.4-13.5	0.6-7.0	2-6
Mean	A	3.1	2.5	5.6	2.8	2.5	3.6
	F	2.8	2.6	6.2	3.6	2.5	3.3

Q-Results Questionable

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NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

Variable - Measurements - Season		Station					
		Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Median	A	2.0	2.0	4.2	2.4	2.3	2.8
		2.3	2	4.4	3.2	2.4	2.8
Total Organic Carbon mg/L							
Years		1973-91	1973-81	1973-82	1973-82	1973-82	1974-79
Samples No,	A	101	78	109	106	75	43
	F	23	18	24	23	18	5
Range	A	<0-48	0-45	0.5-45	0-50	<0-23	1-49
	F	2-15	2-22	6-25	1-22	3-20	5-14
Mean	A	9.2	10.1	15.2	9.1	9.9	12.3
	F	8.0	8.7	13.5	9.0	9.0	8.6
Median	A	7	9.0	13	8.0	9	9
	F	8.0	7.0	11.5	9	9.0	8
Total Suspended Solids mg/L Years		1971-82	1970-82	1970-82	1970-82	1971-82	1971-79
Samples No.	A	162	154	189	185	121	99
	F	38	37	43	43	29	11
Range	A	4-1277	2-1564	3-1992	2-1580	3-1018	2-1524
	F	5-196	2-324	13-198	7-279	5-111	24-163

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WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

Variable - Measurements - Season		Station					
		Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Mean	A	74	106	106	87	100	102
	F	32	45	41	35	29	47
Median	A	27	29	34	28	36	32.5
	F	23	26	29	23	25	31
Nitrogen, Total Kjeldahl mg/L Years		1971-82	1971-82	1971-82	1971-82	1972-82	1981-79
Samples No.	A	154	129	164	162	107	78
	F	35	31	37	38	26	8
Range	A	0.1-17	0.2-3.8	0.16-5.7	0.2-3.7	0.2-11.4	0.1-7.1
	F	0.1-3.3	0.3-3	0.16-3	0.2-3	0.2-1.2	0.6-2.6
Mean	A	1.16	1.14	1.32	1.07	1.05	1.37
	F	0.88	0.97	1.05	0.92	0.69	1.41
Median	A	0.86	0.9	1.00	0.90	0.8	1.2
	F	0.6	0.8	0.9	0.90	0.59	1.05
Phosphorus, Total mg/L Years		1971-82	1970-82	1970-82	1970-82	1971-82	1971-79
Samples No.	A	164	155	189	185	120	100
	F	41	37	43	43	29	11
Range	A	<0.01-2.60	0-0.46	<0.01-0.50	<0.01-0.70	0-0.56	0.009-0.7
	F	<0.01-0.46	0-0.24	<0-01-0.32	<0.0.-0.27	0-0.33	<0.01-0.09

APPENDIX 2

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
WATER QUALITY NETWORK STATIONS
HISTORICAL SUMMARY - SELECTED DATA

Variable - Measurements - Season		Station					
		Opp. P.A. WTP (R2)	PAPCO Intake (R8 off left bank)	Cecil Ferry 1/3 North Bank (R10-0.33 LB)	Cecil Ferry 1/3 South Bank (R10-0.33 RB)	Cole Rapids (R12-RB)	At Confluence (R13)
Mean	A	0.104	0.092	0.101	0.101	0.109	0.078
	F	0.067	0.066	0.069	0.069	0.063	0.036
Median	A	0.70	0.08	0.08	0.08	0.080	0.07
	F	0.04	0.05	0.06	0.05	0.06	0.03

APPENDIX 3

PRINCE ALBERT STORM SEWER QUALITY IN SUMMER 1982 AND ON OCTOBER 17 AND OCTOBER 31, 1983

Appendix 3. Table A3.1

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
QUALITY CHARACTERISTICS - EFFLUENTS - PRINCE ALBERT STORM SEWAGE (1982)*

Location: Dates (1982):	8 Ave. W 0517: 0921 1026	of 6 Ave. (WTP 0504; 0621 0921; 1026	6 Ave. W 0621; 0921 1026	6 Ave. E 0621; 0921 1026	8 Ave. E 0517; 0621 0921; 1026
		Range of Values (in mg/L unless noted)			
Conductance, uS/cm	752-1459	445-1139	756-1080	1720-2640	690-1054
Chloride	32-62	2-114	10-30	96-152	18-54
Organic Carbon	83-87	1-114	38-400	138-310	48-90
BOD_5	0.6-17.6	1.0-85		1.2-48	
TSS	14-118	6-462	365-546	5-52	22-1575
Total Phosphorus	0.04-0.40	0.60-4.9	10.5-42.0	0.14-6.75	0.09-0.65
Ortho phosphorus	0.12-10.18	0.05-3.00	0.6-5.25	0.23-1.00	0.03-0.15
Total Kjeldahl Nitrogen	0.8-2.0	2.0-30	48-440	1.8-5.5	0.5-17
Ammonia Nitrogen	10.01-0.06	0.06-22.75	0.15-11.6	0.12-0.37	10.01-0.05
Nitrate Nitrogen	3.75-14.53	0.07-0.88	10.03-0.24	0.14-16.90	5.75-10.48
Total Coliforms/100 ml	90-46000	90->30000	>23000->30000	3000->23000	430->30000
Fecal Coliforms/100 ml	130-390	40->23000	> 3000-460000	130-110000	40-4600

Note: Coliform data grouped both MPN & MF techniques.

* from McDonald (1983)

APPENDIX 3 Table A3.2 PRINCE ALBERT STORM SEWAGE QUALITY
OCTOBER 17 AND OCTOBER 31, 1983

Location:	8th Ave. W.		West of 6th Ave.		6th Ave. W.		6th Ave. E.			8th Ave. E.	
Date:	831017	831031	831017	831031	831017	831031	831017	(Duplicate)	831031	831017	831031
Time:	11:50	13:00	12:00	13:10	12:12	13:00	12:30	(12:35)	13:40	12:55	13:50
Total Coliforms, /100 mL	Q1100	Q700	40000	<100	46000	300,000	Q6000	(Q45000)	Q8000	E1000	Q1600
Fecal Coliforms, /100 mL	Q40	<10	Q15000	<10	Q2000	Q69000	3900	(5200)	Q1220	640	Q10
Fecal Streptococci, /100 mL	<10	<10	Q25300	<10	85000	770000	620	(740)	640	10	Q120
Temperature, °C	8.2	9	10	4	24	24	10	(10)	11	5	8
Dissolved Oxygen, mg/L	11.6	10.4	8.2	12.6	6.3	5.4	9.9	(9.7)	9.5	7.8	6.7
% Oxygen Saturation	103	95	76	101	78	67	92	(91)	90	64	60
Biochemical Oxygen Demand, mg/L	0.8	0.6	27.0	Lab Acc	Lab Acc	700.0	2.8	(2.8)	4.0	6.0	7.0
Dissolved Organic Carbon, mg/L	8.8	9	14.7	4	244	195	15.4	(14.0)	14	8.2	8
Total Suspended Solids, mg/L	4	3	39	61	129	284	12	(13)	10	18	23
Volatile Suspended Solids, mg/L	2	2	19	10	105	215	3	(4)	4	9	10
Nitrogen, Total Kjeldahl, mg/L	1.2	1.0	12.5	1.3	7.5	14.0	2.1	(2.6)	2.1	1.5	1.7
Nitrogen, Nitrate, mg/L	12.51	10.82	0.64	0.34	<0.03	<0.03	12.17	(11.15)	10.14	9.13	5.07
Nitrogen, Ammonia, mg/L	0.04	0.07	7.10	0.12	0.05	0.27	1.00	(1.03)	0.47	<0.02	0.07
Phosphorus, Total, mg/L	0.07	0.04	1.60	0.22	2.20	4.20	1.10	(1.05)	1.40	0.11	0.10
Phosphorus, ortho, mg/L	0.05	0.07	0.60	0.01	1.80	1.50	0.24	(0.19)	0.21	0.04	0.05
pH (field), units	8.3	8.2	8.1	8.4	9.9	10.2	8.3	(-)	8.1	8.0	8.0
pH (lab), units	8.1	8.3	7.8	7.5	9.6	9.8	8.1	(8.1)	8.1	7.9	8.0
Specific Conductance, uS/cm	1488	1430	689	693	6590	850	2580	(2559)	2600	1052	860
Total Alkalinity, mg/L $CaCO_3$	388	382	207	140	42	310	566	(568)	560	367	354
Chloride, mg/L	56	52	30	6	16	10	134	(134)	130	44	32
Pentachlorophenol, ug/L	--	--	--	--	--	--	--	--	--	--	65
Appearance	A-0, T-11, F-000 0-000 C-000	A-0,T-11, F-000 0-000 C-000	A-0,T-32, F-210,P-609 C-304	A-1,T-32, F-000,0-318 C-305	A-0,T-32, F-310, 0-516, C-204	A-0,T-4, F-212,0-816, C-207	A-0, T-12, F-000, C-413,C-204		A-0,T-11, F-000,0- 509,C-205	A-0,T-11, F-000,0- 613,C-202	A-0,T-12, 0-616,X-205

Q-Results Questionable
E-Estimate

APPENDIX 4

PRINCE ALBERT SEWAGE TREATMENT PLANT
GENERAL EFFLUENT QUALITY, HEAVY METAL AND
TRACE SUBSTANCE CONTENTS, AND CALCULATED
DAILY EFFLUENT DISCHARGE LOADINGS
OCTOBER AND NOVEMBER, 1983 SURVEYS
AND HISTORICAL DATA SUMMARY

APPENDIX 4
TABLE A4.1

PRINCE ALBERT SEWAGE TREATMENT PLANT
EFFLUENT QUALITY - GENERAL
OCTOBER AND NOVEMBER 1983 SURVEYS

Sample Type:	Grab		Composite		Grab		Composite	
Date (s):	831018	831019	831017-18	831018-19	831101	831102	831031-1101	831101-02
Time (s):	09:45	10:45	15:00 - 16:45	16:40 - 16:45	10:40	10:32	16:45 - 16:48	16:45 - 16:45
Total Coliforms, /100 mL	5,200,000	41,000,000	5,200,000	3,200,000	6,300,000	440,000	>3,500,000	2,500,000
Fecal Coliforms, /100 mL	360,000	2,100,000	360,000	Q610,000	680,000	Q130,000	>6,900,000	590,000
Fecal Streptococci, /100 mL	Q170,000	530,000	Q170,000	270,000	450,000	77,000	2,900,000	Q220,000
Temperature, °C	14.5	15.5	--	19	--	14	--	--
Dissolved Oxygen, mg/L	--	--	--	--	--	2.3	--	--
% Oxygen Saturation	--	--	--	--	--	23	--	--
Biochemical Oxygen Demand, mg/L	R80.0	R50.0	R140.0	R120.0	R95.0	R95.0	R150.0	R170.0
Dissolved Organic Carbon, mg/L	29	24	20	43	23	26	38	45
Total Suspended Solids, mg/L	87	65	57	85	73	47	46	63
Volatile Suspended Solids, mg/L	55	46	43	56	53	38	39	48
Nitrogen, Total Kjeldahl, mg/L	30.0	30.0	27.5	27.5	25.0	27.5	28.0	31.0
Nitrogen, Nitrate, mg/L	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nitrogen, Ammonia, mg/L	17.50	19.50	21.00	21.00	19.50	18.75	19.50	18.50
Phosphorus, Total, mg/L	4.50	4.25	5.25	5.25	4.30	4.50	5.50	6.25
Phosphorus, ortho, mg/L	3.00	2.25	4.00	4.00	2.65	2.60	4.50	4.97
pH (field), units	7.5	7.5	7.5	7.6	7.7	7.6	7.7	7.6
pH (lab), units	7.4	7.6	7.6	7.7	7.6	7.6	7.5	7.5
Specific Conductance, uS/cm	1480	1794	1417	1455	1638	1840	1280	1380
Total Alkalinity, mg/L $CaCO_3$	314	320	314	325	292	304	304	305
Chloride, mg/L	180	284	160	168	248	292	126	148
Appearance	A-0,T-22,F-111 0-718,C-304	A-0,T-32,F-000 0-609,C-404	A-0,T-21,F-000, C-718,C-304	A-0,T-32,F-210, 0-609,C-304	A-0,T-32,F-210 0-509,0-204	A-0,T-32,F-210 0-709,C-204	A-0,T-32,F-000, 0-609,C-304	A-0,T-32,F-000 0-709,C-304

Q-Result Questionable
R-Poor Depletion in Blank

APPENDIX 4

TABLE A4.2

PRINCE ALBERT SEWAGE TREATMENT PLANT

EFFLUENT QUALITY - HEAVY METALS, TRACE SUBSTANCES

OCTOBER AND NOVEMBER 1983 SURVEYS *

Sample Type:	Grab		Composite		Grab		Composite	
Date (s):	831018	831019	831017-18	831018-19	831101	831102	831031-1101	831101-02
Time (s):								
Aluminum	1.1	0.69	0.56	1.3	0.66	0.38	0.56	0.70
Arsenic	0.0013	0.0012	0.0013	0.0015	0.0015	0.009	0.0012	0.0013
Barium	0.073	0.08	0.082	0.093	0.072	0.076	0.062	0.092
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	0.08	0.12	0.22	0.22	0.09	0.11	0.2	0.17
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	0.008	0.01	0.007	0.07	0.007	0.005	0.006	0.008
Cobalt	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	0.041	0.043	0.046	0.064	0.034	0.032	0.046	0.062
Cyanide, ug/L	0.005	0.0001	0.0002	0.0008	0.014	0.0029	0.0015	0.0021
Iron	1.2	0.63	0.63	1.2	1.3	0.46	0.72	0.68
Lead	0.022	0.012	0.019	0.02	0.014	0.005	0.008	0.018
Manganese	0.14	0.13	0.13	0.11	0.12	0.11	0.088	0.090
Mercury, ug/L	0.00020	0.00015	0.0020	0.00025	0.00040	0.00055	0.00018	0.00015
Molybdenum	0.01	0.01	0.01	0.01	0.06	0.006	0.006	0.006
Nickel	0.001	<0.001	0.003	0.004	0.004	0.005	0.004	0.006
Selenium	0.001	0.002	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Silicon	<0.05	0.2	0.13	0.31	0.1	0.2	0.3	0.2
Silver	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001
Titanium	0.021	0.004	0.004	0.01	0.009	<0.001	0.005	0.004
Vanadium	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Wolfram	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	0.068	0.035	0.049	0.062	0.044	0.048	0.046	0.062
Calcium	>50	>50	>50	>50	>50	>50	>50	>50
Magnesium	41	42	33	34	44	38	34	28
Potassium	11	9.7	11	12	11	9.6	14	11
Sodium	>50	>50	>50	>50	>50	>50	>50	>50
Phosphorus	5.1	4.1	5.7	6.0	4.2	4.2	5.6	5.8

*All values in mg/L

APPENDIX 4

TABLE A4.3 PRINCE ALBERT SEWAGE TREATMENT PLANT
CALCULATED EFFLUENT DISCHARGE LOADINGS (kg/day)
OCTOBER AND NOVEMBER 1983 SURVEYS

Sample Type:	Grab		Composite		Grab		Composite	
Date (s):	831018	831019	831017-18	831018-19	831101	831102	831031-1101	831101 02
Sewage Flow, m³/d	21699	23569	21005	22634	24881	25301	24264	25091
Biochemical Oxygen Demand	R1736	R1178	R2940	R2716	R2364	R2404	R3640	R4265
Dissolved Organic Carbon	629	566	420	973	572	658	922	1129
Total Suspended Solids	1888	1532	1197	1924	1816	1189	1116	1581
Nitrogen (TKN + NO_3-N)	651	707	683	622	622	696	679	778
Phosphorus, Total	98	100	110	119	107	114	133	157
Chloride	3906	6694	3361	3803	6170	7388	3057	3713
Aluminum	23.9	16.3	11.0	29.4	16.4	9.6	13.6	17.6
Arsenic	0.03	0.03	0.03	0.03	0.04	0.02	0.03	0.03
Barium	1.6	1.9	1.7	2.1	1.8	1.9	1.5	2.3
Beryllium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.03	<0.02	<0.03
Boron	1.7	2.8	4.6	5.0	2.2	2.8	4.9	4.3
Cadmium	<0.02	<0.03	<0.02	<0.02	<0.02	<0.03	<0.02	<0.03
Chromium	0.2	0.2	0.1	0.3	0.2	0.1	0.1	0.2
Cobalt	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03
Copper	0.9	1.0	1.0	1.4	0.8	0.8	1.1	1.6
Cyanide	0.01	0.002	0.004	0.018	0.348	0.073	0.036	0.053
Iron	26.0	14.8	13.2	27.2	32.3	11.6	17.5	17.1
Lead	0.5	0.3	0.4	0.5	0.3	0.1	0.2	0.5
Manganese	3.0	3.1	2.7	2.5	3.0	2.8	2.1	2.3
Mercury	0.004	0.004	0.004	0.006	0.010	0.014	0.004	0.004
Molybdenum	0.2	0.2	0.2	0.2	1.5	0.2	0.1	0.2
Nickel	0.02	<0.02	0.06	0.09	0.1	0.1	0.1	0.2
Selenium	0.02	0.09	0.02	0.02	<0.02	<0.03	<0.02	<0.03
Silicon	<1.1	4.7	2.7	7.0	2.5	5.1	7.3	5.0
Silver	<0.02	<0.02	<0.02	0.05	<0.02	<0.03	<0.02	<0.003
Titanium	0.5	0.1	0.8	0.2	0.2	0.03	0.1	0.1
Vanadium	0.4	0.5	0.4	0.5	0.2	0.3	0.2	0.3
Wolfram	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	1.5	0.8	1.0	1.4	1.1	1.2	1.1	1.6

R-Poor Depletion in Blank

TABLE A4.4

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
QUALITY CHARACTERISTICS - EFFLUENTS
PRINCE ALBERT PRIMARY SEWAGE EFFLUENT

Saskatchewan Environment Data

Variable (in mg/L unless noted)	Data Review Period	Range	Average	Estimated Quantity @ 0.22 m^3/s (kg/d)
pH, units	8201-8307	7.1-7.6		
Conductance	8201-8307	1230-2280	1510	
TDS	8205	872-964	920	
Alkalinity, mg/L ($CaCO_3$)	8201-8307	222-355	238	5,700
Chloride	8201-8307	52-404	213	4,050
Sulphate	8205-8206	110-116	114	
Calcium	8205	46-50	48	
Magnesium	8205	31-35	33	
Potassium	8205	11-18	15	
Sodium	8205	166-183	175	
Organic Carbon	8201-8207	81-273	104	
BOD_5	8201-8307	44-220	136	2590
TSS	8201-8307	84-236	160	3040
VSS	8201-8307	55-152	103	1960
Total Phosphorus	8201-8307	4.6-12.0	7.1	135
Ortho Phosphorus	82-1-8307	2.0-9.0	4.8	91
Total Kjeldahl Nitrogen	8201-8307	25.0-62.5	38.5	732
Total Ammonia Nitrogen	8201-8307	12.0-31.75	22	418
Total Coliforms, MPN/ml	8201-8307	>23000		
Fecal Coliform, MPN/ml	82-1-8307	>23000		

TABLE A4.4

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA

QUALITY CHARACTERISTICS - EFFLUENTS

PRINCE ALBERT PRIMARY SEWAGE EFFLUENT

Saskatchewan Environment Data

Variable (in mg/L unless noted)	Data Review Period	Range	Average	Estimated Quantity
Aluminum	7901-8111	0.39-3.1	2	173
Arsenic	7901-8110	<0.001-0.0025	<0.0018	0.16
Barium	7901-8111	0.10-0.23	0.15	13
Beryllium	8007-8111	<0.001	<0.001	<0.09
Boron	7801-8110	0.18-0.34	0.22	19
Cadmium	7801-8111	0.0015-0.06	<0.03	<2.6
Chromium	7801-8111	0.012-0.35	0.098	8.5
Cobalt	7801-8111	0.001-<0.10	<0.05	<4.3
Copper	7801-8110	0.094-0.10	<0.10	<8.6
Cyanide	7801-8111	<0.0001-0.22	0.037 (biased by one result)	
Lead	7801-8111	0.039-<0.10	<0.066	<5.7
Mercury	7801-8203	0.00010-0.00040	0.00023	0.02
Nickel	7801-8111	0.011-<0.14	<0.064	15.7
Selenium	7801-8111	<0.001	<0.001	<0.09
Silver	7801-8111	0.002-<0.034	<0.034	<2.9
Zinc	7801-8111	0.13-0.30	0.22	19

APPENDIX 5

PRINCE ALBERT PULP COMPANY GENERAL
EFFLUENT QUALITY, HEAVY METAL AND TRACE SUBSTANCES
CONTENTS, AND CALCULATED DAILY EFFLUENT DISCHARGE LOADINGS
OCTOBER AND NOVEMBER, 1983 SURVEYS
AND HISTORICAL DATA SUMMARY

APPENDIX 5

TABLE A5.1

PRINCE ALBERT PULP CO.
EFFLUENT QUALITY - GENERAL
OCTOBER AND NOVEMBER 1983 SURVEYS

Date:	831018	831019	831020	831101	831102	831103
Time:	13:00	09:00	10:40	14:00	10:30	11:00
Total Coliforms, /100 mL	850,000	780,000	600,000	2,100,000	2,100,000	3,300,000
Fecal Coliforms, /100 mL	150,000	290,000	250,000	Q2,140,000	Q1,150,000	260,000
Fecal Streptococci, /100 mL	Q10	<10	Q10	Q10	Q10	10
Temperature, °C	24.0	23.0	--	--		--
Biochemical Oxygen Demand, mg/L	R40.0	R46.0	R42.0	R55.0	R55.0	30.0
Dissolved Organic Carbon, mg/L	92	196	182	230	248	227
Total Suspended Solids, mg/L	85	78	79	81	56	66
Volatile Suspended Solids, mg/L	68	59	64	65	46	53
Nitrogen, Total Kjeldahl, mg/L	6.5	7.5	8.0	6.5	7.5	8.0
Phosphorus, Total, mg/L	0.75	0.85	0.85	0.85	0.80	0.70
pH (field), units	7.4	7.5	--	7.5	7.5	--
pH (lab), units	7.2	7.4	7.3	7.5	7.4	7.5
Specific Conductance, uS/cm	2640	2540	4560	2490	2520	2520
Total Alkalinity, mg/L $CaCO_3$	275	264	275	308	309	317
Chloride, mg/L	640	670	660	560	560	560
Colour, APHA units	1200	1200	1100	1300	1300	1200
Resin Acids, mg/L	0.7	0.8	0.62	0.28	0.45	0.3
Sulphides, mg/L	4.1	0.9	0.6	0.9	1.2	1.4
Mercaptans, mg/L	0.7	4.6	3.8	5.8	6.1	5.8
Appearance	A-0,T-32,F-110, 0-919,C-408	A-0,T-32,F-110, 0-919, C-408	--	--	--	--

Q-Result Questionable
R-Poor Depletion in Blank

APPENDIX 5

TABLE A5-2

PRINCE ALBERT PULP CO.

EFFLUENT QUALITY - HEAVY METALS, TRACE SUBSTANCES

OCTOBER & NOVEMBER 1983 SURVEYS

	Date:	831018	831019	831020	831101	831102	831103
	Time:	13:00	09:00	10:40	14:00	10:30	11:00
Aluminum, mg/L		1.7	1.7	1.9	1.3	1.3	1.4
Arsenic, mg/L		0.0020	0.0022	0.0022	0.0018	0.0016	0.0016
Barium, mg/L		0.17	0.26	0.073	0.24	0.24	0.24
Beryllium, mg/L		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron, mg/L		0.04	0.02	0.02	0.03	0.04	0.03
Cadmium, mg/L		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/L		0.18	0.17	0.16	0.38	0.26	0.32
Cobalt, mg/L		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/L		0.006	0.005	0.009	0.004	0.064	0.005
Cyanide, mg/L		<0.0001	<0.0001	<0.003	<0.0001	<0.0001	<0.0001
Iron, mg/L		1.3	1.2	1.5	1.2	1.2	1.2
Lead, mg/L		0.005	0.008	0.005	0.005	0.005	0.005
Manganese, mg/L		1.1	1.0	1.0	0.78	0.78	0.82
Mercury, mg/L		0.00035	0.00015	0.00015	0.00010	0.00015	0.00010
Molybdenum, mg/L		0.01	0.01	0.02	<0.005	0.008	0.008
Nickel, mg/L		0.005	0.003	0.005	0.007	0.007	0.006
Selenium, mg/L		<0.001	<0.001	<0.001	<0.006	<0.006	<0.006
Silicon, mg/L		0.18	0.07	<0.05	0.2	0.3	0.3
Silver, mg/L		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium, mg/L		0.016	0.016	0.018	0.013	0.012	0.014
Vanadium, mg/L		0.01	0.01	0.02	0.01	0.01	0.01
Wolfram, mg/L		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc, mg/L		1.6	0.21	0.33	0.26	0.64	0.3
Calcium, mg/L		<50	<50	<50	<50	<50	<50
Magnesium, mg/L		17	16	17	20	16	17
Potassium, mg/L		15	15	15	19	15	15
Sodium, mg/L		>50	>50	>50	>50	>50	>50
Phosphorus, mg/L		0.7	0.7	0.8	0.7	0.7	0.7

APPENDIX 5

TABLE A5-3

PRINCE ALBERT PULP CO.
CALCULATED EFFLUENT DISCHARGE LOADINGS (kg/day)
OCTOBER AND NOVEMBER 1983 SURVEYS

Grab Sample Date: Effluent Flow, m³/d	831018 95400	831019 95000	831020 91600	831101 90800	831102 84300	831103 95500
Biochemical Oxygen Demand	R3816	R4370	R3847	R4994	R4637	2865
Dissolved Organic Carbon	8777	18620	16671	20884	20906	21679
Total Suspended Solids	8109	7410	7236	7355	4721	6303
Nitrogen (TKN)	620	713	733	590	632	764
Phosphorus, Total	72	81	78	77	67	67
Chloride	61056	63650	60456	50848	47208	53480
Resin Acids	66.8	76.0	56.8	25.4	38.0	28.7
Sulphides	391.1	85.5	55.0	81.7	101.2	133.7
Mercaptans	66.8	437.0	348.1	526.6	514.2	553.9
Aluminum	162.2	161.5	174.0	118.0	109.6	133.7
Arsenic	0.2	0.2	0.02	0.2	0.1	0.2
Barium	16.2	24.7	6.7	21.8	20.2	22.9
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	3.8	1.9	1.8	2.7	3.8	2.9
Cadmium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	17.2	16.2	14.7	34.5	30.3	30.6
Cobalt	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	0.6	0.5	0.8	0.4	5.4	0.8
Cyanide	<0.01	<0.01	0.3	<0.01	<0.01	<0.01
Iron	124.0	114.0	137.4	109.0	101.2	114.6
Lead	0.5	0.8	<0.5	<0.5	<0.4	<0.5
Manganese	104.0	95.0	91.6	70.8	65.8	78.3
Mercury	0.03	0.01	0.01	0.01	0.01	0.01
Molybdenum	1.0	1.0	1.8	<0.5	0.7	0.8
Nickel	0.5	0.3	0.5	0.6	0.6	0.6
Selenium	<0.1	<0.1	<0.1	0.5	<0.5	<0.6
Silicon	17.2	6.7	4.6	18.2	25.3	28.7
Silver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Titanium	1.5	1.5	1.6	<1.2	1.0	1.3
Vanadium	0.9	1.0	1.8	0.9	0.8	1.0
Wolfram	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5
Zinc	152.6	20.0	30.2	23.6	54.0	28.7

R-Poor Depletion in Blank

TABLE A5-4

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
QUALITY CHARACTERISTICS - EFFLUENTS - PRINCE ALBERT PULP CO.

Variable	Average Discharge Nov/81-Nov/82	Comments
pH	6.6 - 8.0 unit range	
Conductance	1,860 uS/cm	
Sodium	50,000 kg/d	
BOD_5	6,700 kg/d	
COD	75,300 kg/d	
TSS	6,600 kg/d	
Colour	2,500 units	
Total Phosphorus	110 kg/d	
Total Kjeldah Nitrogen	390 kg/d	
Resin Acids	530 kg/d	
Sulphides	150 kg/d	
Mercaptans	480 kg/d	
Total Coliforms	190,000/100 ml	
Fecal Coliforms	2,200/100 ml	

APPENDIX 6

RESULTS OF SPECIES IDENTIFICATIONS OF FECAL COLIFORM ISOLATES

APPENDIX 6

Results of species identifications of colonies selected from fecal coliform (FC) membrane filtration analyses of river water and effluent samples obtained during October and November, 1983.

Sample Date	Sample Site Description	Sample Volume Filtered (ml)	Number Target# Colonies Observed	Reported FC Density (count/100 ml)	Number Colonies Identified	Colony Description	Colony Identification
17/Oct./83	R1 .75 RB	100	2	2	1	- typical, blue	Escherichia coli
17/Oct./83	R5 .25 RB	10	5	50	2	- large granular - small dark blue smooth.	E. coli Klebsiella pneumoniae
18/Oct./83	R5 .25 RB	10	8	80	2	- small blue - big blue	Enterobacter cloacae E. coli
17/Oct./83	* PA STP final effluent	0.01	3	77,000	1	- typical, blue, irregular with greyish centre.	E. coli
18/Oct./83	PA STP final effluent	0.001	6	330,000	2	- big, blue - pink-non-target colony	E. coli Pseudomonas sp.
17/Oct./83	** PAPCO Aeration Pond final effluent	0.01	15	150,000	1	- small gray with blue centre	K. pneumoniae
18/Oct./83	R10 .33 LB	1.0	80	8,000	3	- big blue - grey with blue centre. - pink (non-target)	E. coli K. pneumoniae Pseudomonas sp.
18/Oct.83	R12 opp. RB	1.0	13	1,300	2	- big blue - small grey with blue centre.	E. coli K. pneumoniae

APPENDIX 6

Results of species identifications of colonies selected from fecal coliform (FC) membrane filtration analyses of river water and effluent samples obtained during October and November, 1983.

Sample Date	Sample Site Description	Sample Volume Filtered (ml)	Number Target# Colonies Observed	Reported FC Density (count/100 ml)	Number Colonies Identified	Colony Description	Colony Identification
01/Nov./83	R5 10m RB	2.0	209	418	3	- gray blue (green) - blue - large blue	*E. coli* *E. coli* *E. coli*
01/Nov./83	R5 .25 RB	2.0	88	4,400	3	- large, blue - medium blue - greenish blue	*E. coli* *Serratia odorifera* *E. coli*
01/Nov./83	R5 .5 RB	2.0	3	148	1	- blue	*E. coli*
02/Nov./83	R5 .25 RB	25	3	12	2	- green - blue	*K. pneumoniae* *E. coli*
01/Nov./83	*PA STP final effluent	0.001	7	680,000	3	- dark blue - blue grey - blue grey	*Enterobacter cloacae* *K. pneumoniae* *Enterobacter sakazaki*
02/Nov./83	PA STP final effluent 24 hr. composite	0.01	59	590,000	2	- blue - dark blue	*E. coli* *E. coli*
01/Nov./83	*PAPCO aeration pond final effluent	0.01	2.4	214,000	1	- grey blue (greenish)	*K. pneumoniae*
01/Nov./83	R10 .33 RB	1.0	23	2,300	2	- blue - greenish	*Citrobacter freundii* *E. coli*
01/Nov./83	R10 .5 LB	1.0	90	9,000	2	- blue - grey blue	*E. coli* *K. pneumoniae*

APPENDIX 6

Results of species identifications of colonies selected from fecal coliform (FC) membrane filtration analyses of river water and effluent samples obtained during October and November, 1983.

Sample Date	Sample Site Description	Sample Volume Filtered (ml)	Number Target# Colonies Observed	Reported FC Density (count/100 ml)	Number Colonies Identified	Colony Description	Colony Identification
01/Nov./83	R10 .33 LB	0.1	46	46,000	1	-gray blue (greenish)	*K. pneumoniae*
01/Nov./83	R10 10m LB	0.1	17	17,000	1	-grey blue	*K. pneumoniae*
02/Nov./83	R11 10m LB	0.1	24	24,000	1	- grey blue	*K. pneumoniae*
01/Nov./83	R12 RB	0.1	76	76,000	2	- blue - green-gray blue	*E. coli* *K. pneumoniae*
01/Nov./83	R13 RB	1.0	252	25,200	2	- gray blue - blue	*K. pneumoniae* *K. pneumoniae*

* PA STP - Prince Albert Sewage Treatment Plant

** PAPCO - Prince Albert Pulp Company

the membrane filter used for colony identification was not necessarily that used to determine FC density.

83/11/28

KPL/mf

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA DETAILED WATER QUALITY. OCTOBER AND NOVEMBER, 1983 SURVEYS

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R1	R1	R1	R2	R3	R3	R4	R4	R4
Station Location:	.25RB	.50RB	.75RB	off RB	100 m LB	10m LB	10m RB	.25RB	.50RB
Date:	83/10/17	83/10/17	83/10/17	83/10/17	83/10/17	83/10/17	83/10/17	83/10/17	83/10/17
Time:	13:45	13:40	13:30	12:05	14:55	14:50	16:15	16:20	16:25
Total Coliforms, /100 mL	<10	<10	<2	<2	<2	<100	<1000	Q200	<1000
Fecal Coliforms, /100 mL	<1	<1	2	<1	1	60	Q890	Q28	<2
Fecal Streptococci, /100 mL	Q3	Q20	Q9	Q2	<10	210	810	Q32	Q2
Temperature, °C	5.0	5.0	5.0	5.0	6.0	6.0	5.0	4.0	5.5
Dissolved Oxygen, mg/L	14.8	15.0	14.3	14.5	15.2	15.0	14.8	14.9	15.0
% Oxygen Saturation	122	123	118	119	128	127	122	119	125
Biochemical Oxygen Demand, mg/L	4.4	4.8	4.6	4.6	5.0	4.8	5.0	5.0	5.0
Dissolved Organic Carbon, mg/L	3.6	3.6	4.0	3.8	4.3	4.0	4.5	4.0	4.4
Total Suspended Solids, mg/L	9	12	9	17	10	9	17	14	14
Volatile Suspended Solids, mg/L	3	4	3	5	4	3	5	6	4
Nitrogen, Total Kjeldahl, mg/L	0.9	0.9	0.8	1.0	1.0	1.1	0.9	1.1	0.8
Nitrogen, Nitrate, mg/L	0.30	0.24	0.24	0.41	0.30	0.17	0.24	0.30	0.24
Nitrogen, Ammonia, mg/L	0.02	0.04	0.06	0.28	0.06	0.02	0.06	0.02	0.07
Phosphorus, Total, mg/L	0.14	0.14	0.14	0.15	0.12	0.14	0.16	0.13	0.13
Phosphorus, ortho, mg/L	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	0.02	0.06	<0.01
pH (field), units	9.2	9.2	8.8	9.2	9.2	9.2	9.2	9.1	9.2
pH (lab), units	8.8	8.8	9.2	8.8	8.8	8.8	8.8	8.6	8.7
Specific Conductance, uS/cm	40.9	4.6	421	411	413	420	404	410	400
Total Alkalinity, mg/L $CaCO_3$	150	152	154	154	154	152	152	152	154
Chloride, mg/L	10	14	10	8	12	8	10	8	8
Mercury, ug/L	--	--	--	--	--	--	--	--	--
Colour, APHA units	--	--	--	--	--	--	--	--	--
Appearance	lt. brown	sl. turbid lt. green	sl. turbid lt. brown	mod. turbid lt. green	non-desc.	sl. turbid	sl. turbid	non-desc.	sl. turbid

Q-Result Questionable

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect: Station Location: Date: Time:	R-4 .75RB 83/10/17 16:30	R-4 .78RB 83/10/17 Dup. #1	R-5 .25RB 83/10/17 17:15	R-5 .50RB 83/10/17 17:35	R-5 .75RB 83/10/17 17:40	R-5 .25RB 13/10/18 08:45	R-5 .50RB 83/10/18 08:55	R-5 .75RB 83/10/18 09:10	R-5 .25RB 83/10/18 09:26
Total Coliforms, /100 mL	Q16	N2	Q800	Q20	<10	Q100	Q50	Q100	Q50
Fecal Coliforms, /100 mL	Q2	3	Q50	<10	<10	Q80	Q10	Q10	<10
Fecal Streptococci, /100 mL	Q28	7	Q110	Q20	Q10	Q80	Q20	Q20	Q10
Temperature, °C	6.0	--	6.0	6.0	6.0	3.5	3.5	3.5	3.0
Dissolved Oxygen, mg/L	15.1	--	15.4	15.1	15.2	14.5	14.0	14.5	14.3
% Oxygen Saturation	127	--	130	127	128	115	111	115	117
Biochemical Oxygen Demand, mg/L	5.0	5.0	5.5	4.2	4.6	5.0	4.6	4.4	4.2
Dissolved Organic Carbon, mg/L	4.6	3.7	4.0	5.0	3.7	5	5	6	8
Total Suspended Solids, mg/L	12	9	16	13	7	7	9	9	8
Volatile Suspended Solids, mg/L	4	3	8	4	3	3	2	3	3
Nitrogen, Total Kjeldahl, mg/L	0.9	0.9	0.8	1.0	0.7	0.8	1.0	0.8	1.4
Nitrogen, Nitrate, mg/L	0.27	0.24	0.27	0.30	0.20	0.27	0.30	0.27	0.27
Nitrogen, Ammonia, mg/L	0.07	0.02	0.02	0.05	0.02	0.04	0.04	0.04	0.16
Phosphorus, Total, mg/L	0.12	0.14	0.14	0.12	0.13	0.15	0.13	0.12	0.19
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	0.03	<0.01	0.04	0.02	0.02	0.03
pH (field), units	9.2	9.2	--	9.2	9.2	8.7	8.9	9.0	8.9
pH (lab), units	8.8	8.9	8.8	8.8	8.8	8.6	8.7	8.8	8.8
Specific Conductance, uS/cm	403	410	412	424	410	415	424	400	394
Total Alkalinity, mg/L $CaCO_3$	156	152	152	156	150	155	153	151	152
Chloride, mg/L	12	10	10	22	8	10	6	10	12
Mercury, ug/L	--	--	<0.02	0.02	0.02	<0.02	<0.02	<0.02	<0.02
Colour, APHA units	--	--	--	--	--	--	--	--	--
Appearance	non-desc.	non-desc.	sl. turbid	--	--	sl. turbid lt. grey	sl. turbid lt. grey	--	sl. turbid lt. green

Q-Result Questionable
N-Interference

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-5	R-5	R-6	R-6	R-6	R-6	R-7	R-7	R-7
Station Location:	.50RB	.75RB	.10m RB	.25RB	.50RB	.75RB	10m RB	.25RB	.50RB
Date:	83/10/19	83/10/19	83/10/18	83/10/18	83/10/18	83/10/18	83/10/18	83/10/18	83/10/18
Time:	09:31	09:35	12:00	12:15	12:03	12:11	12:15	12:27	12:30
Total Coliforms, /100 mL	<10	<10	Q31000	Q100	Q100	Q200	Q100	220	3900
Fecal Coliforms, /100 mL	<10	<10	Q10700	<10	<10	Q20	<10	Q520	410
Fecal Streptococci, /100 mL	<10	<10	750	<10	<10	Q10	Q10	310	Q40
Temperature, °C	3.0	3.5	5.0	4.0	5.0	5.0	4.5	5.0	5.0
Dissolved Oxygen, mg/L	14.1	14.6	14.8	14.5	15.1	14.3	14.9	16.3	15.2
% Oxygen Saturation	110	116	122	116	104	99	121	134	126
Biochemical Oxygen Demand, mg/L	4.0	4.0	6.0	5.0	5.0	4.6	4.8	5.0	4.8
Dissolved Organic Carbon, mg/L	7	5	4	4	4	5	5	4	5
Total Suspended Solids, mg/L	8	7	8	7	10	11	19	12	9
Volatile Suspended Solids, mg/L	2	2	3	1	2	5	3	3	3
Nitrogen, Total Kjeldahl, mg/L	1.0	0.9	1.3	0.8	1.3	1.2	0.9	0.9	1.2
Nitrogen, Nitrate, mg/L	0.27	0.24	0.30	0.27	0.20	0.12	0.14	0.30	0.27
Nitroger, Ammonia, mg/L	0.03	0.10	0.07	0.03	0.02	0.07	0.02	0.02	0.02
Phosphorus, Total, mg/L	0.15	0.13	0.20	0.13	0.13	0.13	0.13	0.16	0.13
Phosphorus, ortho, mg/L	0.03	0.03	0.04	0.02	<0.01	<0.01	0.01	0.04	0.01
pH (field), units	8.9	8.9	9.1	9.1	9.1	9.0	9.1	9.1	9.1
pH (lab), units	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Specific Conductance, uS/cm	392	391	412	398	402	409	406	404	380
Total Alkalinity, mg/L $CaCO_3$	151	151	151	151	155	160	161	151	151
Chloride, mg/L	10	20	12	12	10	10	10	14	12
Mercury, ug/L	0.52	0.03	--	--	--	--	--	--	--
Colour, APHA units	--	--	--	--	--	--	--	--	--
Appearance	sl. trubid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	med. turbid lt. green sl. septic	sl. turbid lt. green

Q-Result Questionable

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-7	R-7	R-7	R-7	R-7	R-8	R-8	R-8	R-8
Station Location:	.75RB	10m RB	.25RB	.50RB	.75RB	10m RB	10m RB	.25RB	.50RB
Date:	83/10/18	83/10/19	83/10/19	83/10/19	83/10/19	83/10/18	83/10/18	83/10/18	83/10/18
Time:	12:33	12:05	12:07	12:10	12:15	12:50	Dup. #4	13:00	13:05
Total Coliforms, /100 mL	Q300	Q13100	Q13400	2100	<10	Q9000	Q15200	4600	2800
Fecal Coliforms, /100 mL	Q70	3100	2400	320	<10	>1400	Q1200	420	320
Fecal Streptococci, /100 mL	Q20	700	290	Q30	Q20	300	Q70	Q70	220
Temperature, °C	5.0	3.0	3.0	3.0	3.0	4.5	--	4.5	5.0
Dissolved Oxygen, mg/L	15.1	15.4	13.9	14.4	T	14.2	--	14.3	15.3
% Oxygen Saturation	124	120	109	113	T	115	--	116	126
Biochemical Oxygen Demand, mg/L	4.8	4.6	4.8	4.8	4.6	4.8	4.8	5.0	5.0
Dissolved Organic Carbon, mg/L	4	5	5	5	5	5	5	5	5
Total Suspended Solids, mg/L	5	6	10	7	7	11	13	7	7
Volatile Suspended Solids, mg/L	2	1	1	3	2	4	5	3	3
Nitrogen, Total Kjeldahl, mg/L	1.3	1.2	1.3	1.0	1.0	0.9	1.0	0.9	0.9
Nitrogen, Nitrate, mg/L	0.30	0.27	0.24	0.27	0.24	0.30	0.27	0.30	0.30
Nitrogen, Ammonia, mg/L	0.03	0.02	0.02	0.07	0.03	0.05	0.02	0.04	0.02
Phosphorus, Total, mg/L	0.18	0.17	0.14	0.15	0.15	0.15	0.15	0.14	0.14
Phosphorus, ortho, mg/L	0.02	0.03	0.02	0.02	0.01	0.02	0.01	0.02	0.02
pH (field), units	9.1	8.9	8.9	8.9	8.9	9.1	--	9.1	9.1
pH (lab), units	8.9	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Specific Conductance, uS/cm	390	397	395	395	402	400	401	400	402
Total Alkalinity, mg/L $CaCO_3$	152	152	151	152	152	152	151	150	151
Chloride, mg/L	14	10	10	12	9	12	10	12	16
Mercury, ug/L	--	--	--	--	--	<0.02	--	<0.02	0.02
Colour, APHA units	--	--	--	--	--	5	--	5	5
Appearance	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	med. turbid lt. green	med. turbid lt. green	med. turbid lt. green	med. turbid lt. green

Q-Result Questionable
T-Broken in Transit

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
Station Location:	off LB	10m RB	.25RB	.50RB	off LB	10m RB	10m RB	.50RB	.75RB
Date:	83/10/18	83/10/19	83/10/19	83/10/19	83/10/19	83/10/20	83/10/20	83/10/20	83/10/20
Time:	13:10	12:30	12:35	12:42	12:46	09:45	Dep. #7	09:55	10:00
Total Coliforms, /100 mL	Q300	Q13700	6200	Q1100	Q300	Q1000	>8000	Q7000	4200
Fecal Coliforms, /100 mL	Q20	3200	Q880	230	Q20	Q600	4700	7600	400
Fecal Streptococci, /100 mL	Q10	670	740	570	Q10	930	Q1040	580	Q20
Temperature, °C	5.0	3.0	3.0	2.0	3.0	--	--	--	--
Dissolved Oxygen, mg/L	T	T	T	T	14.9	14.1	--	14.8	15.6
% Oxygen Saturation	T	T	T	T	116	--	--	--	--
Biochemical Oxygen Demand, mg/L	4.6	4.4	5.0	5.0	4.6	5.5	4.4	5.0	4.0
Dissolved Organic Carbon, mg/L	14	5	5	5	5	5	6	6	7
Total Suspended Solids, mg/L	12	9	6	6	9	3	6	9	1
Volatile Suspended Solids, mg/L	4	2	3	3	4	1	2	2	1
Nitrogen, Total Kjeldahl, mg/L	1.0	1.0	0.9	0.9	1.1	1.2	1.1	0.9	1.0
Nitrogen, Nitrate, mg/L	0.17	0.30	0.34	0.30	0.20	0.20	0.20	0.14	0.10
Nitrogen, Ammonia, mg/L	0.02	0.01	0.02	0.05	0.03	0.02	0.05	0.05	0.03
Phosphorus, Total, mg/L	0.14	0.16	0.14	0.13	0.13	0.13	0.17	0.14	0.12
Phosphorus, ortho, mg/L	0.01	0.02	0.02	0.03	0.01	0.02	0.01	0.02	0.02
pH (field), units	9.1	8.9	8.9	8.9	8.9	--	--	--	--
pH (lab), units	8.8	8.4	8.7	8.8	8.8	8.8	8.6	8.7	8.7
Specific Conductance, uS/cm	4.0	399	396	402	402	400	402	398	408
Total Alkalinity, mg/L $CaCO_3$	157	391	152	153	158	153	152	152	158
Chloride, mg/L	10	12	10	10	10	10	14	12	10
Mercury, ug/L	0.02	0.02	0.02	0.02	0.02	Q0.05	--	Y0.10	Q0.04
Colour, APHA units	6	4	5	5	6	5	--	5	5
Appearance	med. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	sl. turbid lt. green	--	--	--	--

Q-Result Questionable
T-Broken in Transit

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-8	R-9	R-9	R-9	R-9	R-8	R-9	R-9	R-9
Station Location:	off LB	10m RB	.25RB	.50RB	.75RB	10m LB	10m RB	.25RB	.50RB
Date:	83/10/20	83/10/18	83/10/18	83/10/18	83/10/18	83/10/18	83/10/19	83/10/19	83/10/19
Time:	10:05	13:42	13:38	13:35	13:30	13:25	10:00	10:05	10:10
Total Coliforms, /100 mL	Q1200	Q8400	Q9800	3800	5600	350,000	6500	25000	Q900
Fecal Coliforms, /100 mL	230	Q1200	Q910	330	510	Q250,000	Q350	Q2080	Q50
Fecal Streptococci, /100 mL	Q40	410	220	Q40	Q50	Q40	Q950	610	610
Temperature, °C	--	5.0	5.0	4.5	4.0	10.0	--	4.0	4.0
Dissolved Oxygen, mg/L	14.1	15.2	14.4	15.6	14.4	6.6	T	14.8	14.5
% Oxygen Saturation	--	125	118	126	115	62	--	118	116
Biochemical Oxygen Demand, mg/L	4.2	4.0	4.8	4.6	4.8	1.0	4.0	5.0	5.5
Dissolved Organic Carbon, mg/L	10	4	4	5	4	82	6	5	5
Total Suspended Solids, mg/L	15	7	15	15	10	25	6	9	9
Volatilu Suspended Solids, mg/L	3	3	4	4	4	17	2	4	2
Nitrogen, Total Kjeldahl, mg/L	1.2	0.9	1.1	0.9	1.0	3.0	1.0	1.8	0.9
Nitrogen, Nitrate, mg/L	0.07	0.34	0.24	0.24	0.27	N	0.30	0.20	0.27
Nitrogen, Ammonia, mg/L	0.20	0.07	0.02	0.23	0.02	0.02	0.06	0.02	0.02
Phosphorus, Total, mg/L	0.19	0.14	0.15	0.13	0.14	0.30	0.19	0.19	0.14
Phosphorus, ortho, mg/L	0.02	0.01	<0.01	0.04	<0.01	<0.01	0.04	0.02	0.02
pH (field), units	--	9.0	9.1	9.1	9.1	8.1	9.1	9.1	9.1
pH (lab), units	8.6	8.8	8.8	8.7	8.8	7.9	8.5	8.9	8.9
Specific Conductance, uS/cm	412	400	399	400	400	11046	398	394	394
Total Alkalinity, mg/L $CaCO_3$	159	151	152	153	153	190	376	153	152
Chloride, mg/L	10	8	10	8	8	Y250	12	8	8
Mercury, ug/L	Q0.04	--	--	--	--	--	--	--	--
Colour, APHA units	5	5	5	5	5	1100	5	5	5
Appearance	--	lt. green sl. turbid	lt. green sl. turbid	lt. green sl. turbid	lt. green sl. turbid	mod. turbid mod. turbid strong pulp	lt. brown sl. turbid	--	--

Q-Result Questionable
N-Interference

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-9	R-9	R-10	R-10	R-10	R-10	R-10	R-10	R-10
Station Location:	.75RB	10m LB	.33RB	.33RB	.50LB	.33LB	.33RB	.50LB	.33LB
Date:	83/10/19	83/10/19	83/10/18	83/10/18	83/10/18	83/10/18	83/10/19	83/10/19	
Time:	10:15	10:20	17:20	Dup. #5	17:25	17:30	13:45	13:50	13:35
Total Coliforms, /100 mL	6000	J00	2000	3300	Q700	Q25800	6600	7900	Q20500
Fecal Coliforms, /100 mL	570	2700	270	Q114	260	Q8000	Q900	Q1800	Q8900
Fecal Streptococci, /100 mL	120	Q20	250	139	Q180	230	550	230	Q80
Temperature, °C	4.0	4.0	5.5	--	5.5	5.5	4.5	4.5	4.5
Dissolved Oxygen, mg/L	14.1	15.2	14.4	--	15.3	14.8	15.3	14.5	13.6
% Oxygen Saturation	113	122	120	--	127	123	124	117	110
Biochemical Oxygen Demand, mg/L	5.0	4.8	5.0	6.0	4.8	7.0	3.2	5.0	6.0
Dissolved Organic Carbon, mg/L	5	7	5	4	5	8	6	7	11
Total Suspended Solids, mg/L	9	11	11	7	9	12	7	12	11
Volatile Suspended Solids, mg/L	2	5	4	1	4	5	2	3	2
Nitrogen, Total Kjeldahl, mg/L	0.9	1.2	0.9	1.2	1.0	1.1	1.0	1.0	1.2
Nitrogen, Nitrate, mg/L	0.27	0.17	0.34	0.27	0.27	0.20	0.27	0.20	0.17
Nitrogen, Ammonia, mg/L	0.03	0.02	0.02	0.01	0.12	0.02	0.03	0.05	0.03
Phosphorus, Total, mg/L	0.16	0.17	0.15	0.13	0.14	0.14	0.15	0.17	0.14
Phosphorus, ortho, mg/L	0.03	0.0.	0.01	0.01	0.02	0.01	0.03	0.01	0.01
pH (field), units	9.1	9.1	9.0	--	9.1	9.0	9.2	9.1	9.1
pH (lab), units	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Specific Conductance, uS/cm	394	422	402	395	404	450	395	411	460
Total Alkalinity, mg/L $CaCO_3$	152	151	152	227	151	156	152	154	158
Chloride, mg/L	10	16	10	8	8	20	12	16	26
Mercury, ug/L	--	--	0.02	--	<0.02	<0.02	<0.02	<0.02	<0.02
Colour, APHA units	5-	17	6	--	7	36	5	15	35
Appearance	--	--	mod. turbid lt. green sl.slough odor	mod. turbid lt. green sl.slough odor	mod. turbid lt. green lt. green	lt. yellow mod. turbid mod.pulp odor	--	--	--

Q-Result Questionable

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-10	R-10	R-10	R-10	R-11	R-11	R-11	R-11	R-12
Station Location:	.33RB	.50LB	.33LB	.33LB	.75RB	.50LB	.25LB	.25LB	off LB
Date:	83/10/20	83/10/20	83/10/20	83/10/20	83/10/19	83/10/19	83/10/19	83/10/19	83/10/19
Time:	09:35	09:40	09:45	Dup. #9	15:00	15:05	15:10	Dup. #6	11:20
Total Coliforms, /100 mL	Q2000	<1000	Q20000	>8000	Q8500	Q10200	Q17400	Q22400	Q9200
Fecal Coliforms, /100 mL	Q9300	3500	6100	5400	Q1300	4300	5700	<100	Q1300
Fecal Streptococci, /100 mL	Q1600	310	Q190	210	540	280	180	220	220
Temperature, °C	5.0	5.0	5.0	--	--	--	--	--	4.0
Dissolved Oxygen, mg/L	14.6	T	T	--	14.9	15.2	15.1	--	10.3
% Oxygen Saturation	120	T	T	--	--	--	--	--	87
Biochemical Oxygen Demand, mg/L	3.8	3.6	4.2	5.0	5.0	6.0	5.0	6.0	6.0
Dissolved Organic Carbon, mg/L	11	6	5	6	7	8	10	10	6
Total Suspended Solids, mg/L	8	5	12	14	10	16	10	11	11
Volatile Suspended Solids, mg/L	3	1	5	5	4	3	3	3	5
Nitrogen, Total Kjeldahl, mg/L	1.2	1.0	1.1	1.3	1.1	1.1	1.1	1.0	1.1
Nitrogen, Nitrate, mg/L	0.20	0.17	0.20	0.17	0.24	0.20	0.24	0.24	0.17
Nitrogen, Ammonia, mg/L	0.05	0.03	0.03	0.05	0.03	0.01	0.05	0.03	0.04
Phosphorus, Total, mg/L	0.16	0.13	0.13	0.15	0.15	0.15	0.03	0.19	0.13
Phosphorus, ortho, mg/L	0.02	0.02	0.01	0.03	0.01	<0.01	<0.01	0.01	0.01
pH (field), units	9.0	9.0	8.8	--	9.2	9.1	9.0	--	9.0
pH (lab), units	8.6	8.6	8.5	8.5	8.8	8.8	8.8	8.8	8.8
Specific Conductance, uS/cm	403	410	463	465	408	421	443	445	428
Total Alkalinity, mg/L $CaCO_3$	153	154	158	159	154	154	157	158	152
Chloride, mg/L	12	12	26	26	14	16	25	34	10
Mercury, ug/L	<0.02	<0.02	<0.02	--	--	--	--	--	<0.02
Colour, APHA units	5	8	37	--	10	17	28	28	10
Appearance	mod. turbid lt. green sl.stale odor	mod. turbid lt. green	mod. turbid mod. brown mod.pulp odor	mod. turbid mod. brown mod.pulp odor					

Q-Result Questionable
T-Broken in Transit

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-12	R-12	R-12	R-12	R-13	R-13	R-1	R-1	R-1
Station Location:	.33RB	.50RB	off R.B	off R.B	off R.B	off R.B	.25RB	.50RB	.75RB
Date:	83/10/18	83/10/18	83/10/19	83/10/19	83/10/18	83/10/18	83/10/31	83/10/31	83/10/31
Time:	11:10	11:00	15:30	Dup. #8	15:45	Dup. #3	13:55	13:40	13:50
Total Coliforms, /100 mL	Q13300	Q15800	3400	2700	2900	5900	<4	<4	Q4
Fecal Coliforms, /100 mL	4600	Q7100	590	440	210	Q1300	<4	<4	<4
Fecal Streptococci, /100 mL	Q140	300	130	190	Q10	29	<4	Q4	<4
Temperature, °C	4.0	4.0	5.0	--	--	--	4.0	5.0	5.0
Dissolved Oxygen, mg/L	14.2	13.9	14.1	--	--	--	13.5	13.1	13.3
% Oxygen Saturation	113	111	116	--	--	--	108	108	162
Biochemical Oxygen Demand, mg/L	5.5	6.0	6.0	6.0	6.0	6.0	1.6	1.6	1.4
Dissolved Organic Carbon, mg/L	5	7	7	6	7	8	3	3	3
Total Suspended Solids, mg/L	9	12	9	5	8	9	6	7	9
Volatile Suspended Solids, mg/L	4	5	4	1	4	4	2	2	2
Nitrogen, Total Kjeldahl, mg/L	1.0	1.1	1.6	1.3	1.0	1.3	0.5	0.5	0.4
Nitrogen, Nitrate, mg/L	0.20	0.17	0.24	0.20	0.10	0.14	0.30	0.30	0.27
Nitrogen, Ammonia, mg/L	0.02	0.04	0.03	0.03	0.04	0.02	0.03	0.03	0.03
Phosphorus, Total, mg/L	0.12	0.14	0.24	0.14	0.12	0.12	0.05	0.06	0.06
Phosphorus, ortho, mg/L	0.01	0.06	0.02	<0.01	0.01	0.02	<0.01	<0.01	<0.01
pH (field), units	8.2	8.3	9.0	--	8.9	--	8.6	8.6	8.6
pH (lab), units	8.8	8.8	8.9	8.9	8.7	8.8	8.2	8.1	8.2
Specific Conductance, uS/cm	410	410	420	420	426	426	372	374	382
Total Alkalinity, mg/L $CaCO_3$	154	154	155	154	156	154	143	144	146
Chloride, mg/L	18	16	16	16	18	12	4	2	4
Mercury, ug/L	<0.02	0.02	0.02	--	--	--	--	--	--
Colour, APHA units	12	14	11	--	13	--	--	--	--
Appearance	--	sl. turbid lt. rust sl. pulp odor	sl. turbid lt. green sl. pulp odor	sl. turbid lt. green sl. pulp odor	sl. turbid lt. rust	sl. turbid lt. rust	--	--	--

Q-Result Questionable

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-2	R-2	R-3	R-3	R-4	R-4	R-4	R-4	R-5
Station Location:	off RB	off RB	100mLB	10mLB	10mRB	.25RB	.50RB	.75RB	10mRB
Date:	83/10/31	83/10/31	83/10/31	83/10/31	83/10/31	83/10/31	83/10/31	83/10/31	83/10/31
Time:	13:20 -	Dup. #2	14:30	14:35	16:15	16.10	16.05	16:00	16:50
Total Coliforms, /100 mL	<2	Q4	Q4	Q12	>4000	Q12	<4	Q4	Q5000
Fecal Coliforms, /100 mL	<2	<4	<4	Q16	1850	4	<4	<4	1450
Fecal Streptococci, /100 mL	102	Q44	<4	Q8	1450	4	<4	Q8	364
Temperature, °C	5.0	--	5.0	4.5	5.0	5.0	5.0	5.0	4.0
Dissolved Oxygen, mg/L	13.7	--	13.4	14.6	13.3	14.4	13.7	13.3	13.9
% Oxygen Saturation	113	--	110	119	109	118	112	109	112
Biochemical Oxygen Demand, mg/L	1.4	1.6	1.2	1.6	1.8	1.8	1.6	1.2	1.8
Dissolved Organic Carbon, mg/L	4	3	3	3	3	3	3	3	3
Total Suspended Solids, mg/L	7	5	8	7	11	6	9	10	11
Volatile Suspended Solids, mg/L	3	3	2	2	4	2	3	3	3
Nitrogen, Total Kjeldahl, mg/L	0.6	0.7	0.5	0.4	0.8	0.5	0.5	0.5	0.8
Nitrogen, Nitrate, mg/L	0.27	0.27	0.27	0.27	0.31	0.31	0.34	0.31	0.37
Nitrogen, Ammonia, mg/L	0.05	0.05	0.02	0.03	0.03	0.03	0.02	0.03	0.02
Phosphorus, Total, mg/L	0.08	0.09	0.07	0.05	0.09	0.10	0.05	0.07	0.09
Phosphorus, ortho, mg/L	<0.01	0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
pH (field), units	8.7	--	8.7	8.6	8.7	8.7	8.7	8.6	8.7
pH (lab), units	8.2	8.2	8.1	8.2	8.7	8.4	8.3	8.3	8.3
Specific Conductance, uS/cm	381	380	375	82	379	376	376	379	378
Total Alkalinity, mg/L $CaCO_3$	146	152	146	146	145	144	143	144	144
Chloride, mg/L	4	4	4	4	2	4	2	6	4
Mercury, ug/L	--	--	--	--	--	--	--	--	--
Colour, APHA units	--	--	--	--	--	--	--	--	--
Appearance	sl. sloughy odor sl. turbid	sl. sloughy odor sl. turbid	--	--	--	--	--	--	--

Q-Result Questionable

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-5	R-5	R-5	R-5	R-5	R-5	R-5	R-5	R-5
Station Location:	.25RB	.50RB	.75RB	.75RB	10m RB	.25RB	.50RB	.75RB	10m RB
Date:	83/10/31	83/10/31	83/10/31	83/10/31	83/11/01	83/11/01	83/11/01	83/11/01	83/11/02
Time:	16:45	16:40	16:35	Dup. #1	10:25	10:10	10:15	10:20	09:42
Total Coliforms, /100 mL	1450	Q350	<50	Q100	>200	E14500	1050	Q150	Q52
Fecal Coliforms, /100 mL	188	84	Q12	Q4	Q418	Q4400	148	Q4	Q20
Fecal Streptococci, /100 mL	116	Q24	<4	Q12	126	1750	160	Q32	Q12
Temperature, °C	5.0	4.0	4.0	--	--	--	--	--	3.5
Dissolved Oxygen, mg/L	14.4	14.0	13.5	--	12.3	12.6	12.4	12.9	12.5
% Oxygen Saturation	118	112	108	--	--	--	--	---	99
Biochemical Oxygen Demand, mg/L	2.0	1.4	1.6	1.4	4.8	4.0	1.2	1.2	1.2
Dissolved Organic Carbon, mg/L	3	3	3	3	5	4	3	3	3
Total Suspended Solids, mg/L	9	7	8	5	40	18	7	8	7
Volatile Suspended Solids, mg/L	3	2	2	2	9	5	2	3	2
Nitrogen, Total Kjeldahl, mg/L	0.7	0.8	017	1.1	1.0	0.8	0.4	0.5	0.7
Nitrogen, Nitrate, mg/L	0.31	0.30	0.27	0.34	0.30	0.41	0.30	0.27	0.10
Nitrogen, Ammonia, mg/L	0.03	0.03	0.03	0.03	0.14	0107	0.03	0.03	0.01
Phosphorus, Total, mg/L	0.08	0.08	0.08	0.05	0.16	0.16	0.06	0.10	0.07
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.7	8.7	8.7	--	8.4	8.4	8.4	8.5	8.6
pH (lab), units	8.3	8.2	8.2	8.3	8.1	8.2	8.3	8.3	8.3
Specific Conductance, uS/cm	377	372	372	378	385	375	372	372	373
Total Alkalinity, mg/L $CaCO_3$	145	143	145	143	137	141	143	143	142
Chloride, mg/L	4	4	6	4	8	4	4	4	4
Mercury, ug/L	<0.02	<0.02	0.03	--	--	0.04	<0.02	<0.02	--
Colour, APHA units	--	--	--	--	--	--	--	--	--
Appearance	--	--	--	--	--	--	--	--	sl. turbid

Q-Result Questionable
E-Estimate

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-5	R-5	R-5	R-6	R-6	R-6	R-6	R-7	R-7
Station Location:	.25RB	.50RB	.75RB	10m RB	.25RB	.50RB	.75RB	10m RB	.25RB
Date:	83/11/02	83/11/02	83/11/02	83/11/01	83/11/01	83/11/01	83/11/01	83/11/01	83/11/01
Time:	09:48	09:50	09:55	10:57	11:00	11:04	11:10	11:20	11:24
Total Coliforms, /100 mL	Q68	Q4300	<4	Q7000	470	Q30	Q170	>10000	E34000
Fecal Coliforms, /100 mL	Q12	Q850	Q4	Q7000	Q50	Q10	Q40	14900	Q13400
Fecal Streptococci, /100 mL	Q8	232	Q8	930	Q10	Q10	<10	1150	850
Temperature, °C	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.0	4.0
Dissolved Oxygen, mg/L	13.9	12.9	12.9	11.9	12.2	12.8	12.1	12.1	12.4
% Oxygen Saturation	110	102	102	96	98	103	97	97	100
Biochemical Oxygen Demand, mg/L	1.4	1.4	1.2	3.0	1.4	1.4	2.6	2.0	2.0
Dissolved Organic Carbon, mg/L	3	3	3	4	3	3	3	4	3
Total Suspended Solids, mg/L	8	6	8	14	5	7	7	12	8
Volatile Suspended Solids, mg/L	3	2	3	4	2	2	3	3	2
Nitrogen, Total Kjeldahl, mg/L	0.5	1.2	0.5	0.9	0.6	0.7	0.8	0.6	0.7
Nitrogen, Nitrate, mg/L	0.14	0.14	0.14	0.30	0.24	0.24	0.20	0.30	0.30
Nitrogen, Ammonia, mg/L	0.05	0.03	0.03	0.12	0.02	0.03	0.02	0.08	0.07
Phosphorus, Total, mg/L	0.05	0.08	0.05	0.11	0.06	0.06	0.05	0.08	0.08
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.6	8.5	8.6	8.6	8.6	8.6	8.6	8.6	8.6
pH (lab), units	8.3	8.3	8.4	8.3	8.4	8.4	8.4	8.3	8.4
Specific Conductance, uS/cm	372	374	372	377	366	369	377	375	358
Total Alkalinity, mg/L $CaCO_3$	142	142	142	140	143	145	148	143	143
Chloride, mg/L	2	4	4	6	4	4	4	6	4
Mercury, ug/L	0.18	0.07	0.05	--	--	--	--	--	--
Colour, APHA units	--	--	--	--	--	--	--	--	--
Appearance	sl. turbid	sl. turbid	sl. turbid	sl. turbid lt. grey sl.cresote odour	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid

Q-Result Questionable
E-Estimate

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-7	R-7	R-7	R-7	R-7	R-7	R-7	R-7	R-8
Station Location:	.50RB	.75RB	10m LB	10m RB	.25RB	.50RB	.75RB	10m LB	10m RB
Date:	83/11/01	83/11/01	83/11/01	83/11/02	83/11/02	83/11/02	83/11/02	83/11/02	83/11/01
Time:	11:26	11:30	11:36	11:58	12:00	12:02	12:05	12:13	12:20
Total Coliforms, /100 mL	8300	640	Q70	Q25000	Q12000	Q1400	Q1500	Q70	Q20000
Fecal Coliforms, /100 mL	Q860	240	210	4400	5800	470	240	Q50	8000
Fecal Streptococci, /100 mL	Q30	Q20	<10	530	650	Q30	<10	<10	490
Temperature, °C	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	4.0
Dissolved Oxygen, mg/L	12.7	12.2	12.5	15.0	13.5	14.8	13.4	13.0	11.8
% Oxygen Saturation	102	98	100	118	107	117	106	103	95
Biochemical Oxygen Demand, mg/L	1.4	1.6	1.6	2.0	2.2	2.2	1.4	2.0	2.0
Dissolved Organic Carbon, mg/L	3	3	3	3	3	3	3	3	3
Total Suspended Solids, mg/L	11	9	6	8	--	9	9	7	10
Volatile Suspended Solids, mg/L	4	3	1	3	--	3	3	3	2
Nitrogen, Total Kjeldahl, mg/L	0.5	0.5	0.8	0.6	0.7	1.0	0.8	0.7	0.7
Nitrogen, Nitrate, mg/L	0.27	0.24	0.27	0.17	0.14	0.10	0.10	0.14	0.30
Nitrogen, Ammonia, mg/L	0.03	0.03	0.02	0.06	0.03	0.15	0.03	0.05	0.07
Phosphorus, Total, mg/L	0.08	0.06	0.05	0.07	0.09	0.06	0.07	0.07	0.07
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.6	8.6	8.6	8.6	8.5	8.7	8.6	8.6	8.6
pH (lab), units	8.4	8.3	8.4	8.4	8.3	8.4	8.4	8.4	8.4
Specific Conductance, uS/cm	371	367	370	377	375	372	374	376	371
Total Alkalinity, mg/L $CaCO_3$	143	144	145	142	142	143	143	144	144
Chloride, mg/L	4	4	4	4	4	4	4	4	4
Mercury, ug/L	--	--	--	--	--	--	--	--	0.03
Colcur, APHA units	--	--	--	--	--	--	--	--	5
Appearance	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid

Q-Result Questionable

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
Station Location:	.25RB	.50RB	.75RB	10m LB	off LB	off LB	10m RB	.25RB	.50RB
Date:	83/11/01	83/11/01	83/11/01	83/11/01	83/11/01	83/11/01	83/11/02	83/11/02	83/11/02
Time:	12:15	12:12	12:10	12:52	11:55	Dup. #4	12:25	12:30	12:33
Total Coliforms, /100 mL	4600	Q8800	Q1290	Q90	230	Q150	E24000	Q24000	Q19000
Fecal Coliforms, /100 mL	Q500	4300	290	Q20	Q50	Q30	Q6800	Q6500	3600
Fecal Streptococci, /100 mL	490	480	Q30	<10	30	Q10	510	470	240
Temperature, °C	4.0	4.0	4.0	4.0	4.0	--	3.5	3.5	3.5
Dissolved Oxygen, mg/L	12.3	12.3	9.0	12.2	12.6	--	13.4	13.7	13.8
% Oxygen Saturation	99	99	72	98	101	106	107	107	109
Biochemical Oxygen Demand, mg/L	1.8	1.8	1.6	1.4	2.0	1.8	1.6	1.8	1.6
Dissolved Organic Carbon, mg/L	4	3	3	4	3	4	3	3	3
Total Suspended Solids, mg/L	7	7	4	5	15	10	13	13	7
Volatile Suspended Solids, mg/L	2	2	2	2	4	3	4	5	3
Nitrogen, Total Kjeldahl, mg/L	0.6	0.6	0.9	0.6	0.7	0.6	0.9	0.8	0.8
Nitrogen, Nitrate, mg/L	0.30	0.27	0.24	0.24	0.24	0.24	0.17	0.17	0.14
Nitrogen, Ammonia, mg/L	0.03	0.03	0.02	0.03	0.02	0.03	0.08	0.03	0.03
Phosphorus, Total, mg/L	0.07	0.07	0.08	0.04	0.05	0.05	0.12	0.07	0.07
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.6	8.6	8.6	8.6	8.6	--	8.6	8.6	8.6
pH (lab), units	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.3	8.4
Specific Conductance, uS/cm	370	371	374	365	377	381	383	380	375
Total Alkalinity, mg/L $CaCO_3$	143	143	147	147	149	150	145	143	142
Chloride, mg/L	4	4	4	4	4	6	8	4	4
Mercury, ug/L	<0.02	<0.02	--	--	0.04	--	0.05	<0.02	0.04
Colour, APHA units	5	4	5	5	5	--	5	4	5
Appearance	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid	sl. turbid

Q-Result Questionable
E-Estimate

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
Station Location:	.75RB	10m LB	off LB	off LB	10m RB	.25RB	.50RB	.75RB	10m LB
Date:	83/11/02	83/11/02	83/11/02	83/11/02	83/11/03	83/11/03	83/11/03	83/11/03	83/11/03
Time:	12:36	12:40	13:20	Dup. #8	09:40	09:45	09:50	09:30	09:35
Total Coliforms, /100 mL	Q8700	Q900	Q530	290	Q28400	Q5000	Q11100	Q9800	Q1500
Fecal Coliforms, /100 mL	Q1800	Q110	Q120	Q80	Q13600	>600	2100	Q1770	420
Fecal Streptococci, /100 mL	Q100	Q10	<10	Q20	1540	Q1160	Q1600	Q140	Q30
Temperature, °C	3.5	3.5	3.5	--	--	--	--	--	--
Dissolved Oxygen, mg/L	13.9	12.9	13.2	--	12.1	12.5	12.4	12.4	12.0
% Oxygen Saturation	110	102	104	--	--	--	--	--	--
Biochemical Oxygen Demand, mg/L	1.6	1.2	2.6	1.2	R2.0	R2.0	R1.6	R1.2	R1.6
Dissolved Organic Carbon, mg/L	3	3	3	3	4	3	3	3	4
Total Suspended Solids, mg/L	9	17	20	22	--	6	12	7	58
Volatile Suspended Solids, mg/L	4	4	4	5	--	3	4	2	3
Nitrogen, Total Kjeldahl, mg/L	0.7	1.0	0.7	0.5	0.7	0.7	0.7	0.8	1.1
Nitrogen, Nitrate, mg/L	0.17	0.17	0.10	0.14	0.24	0.10	0.14	0.14	0.10
Nitrogen, Ammonia, mg/L	0.03	0.05	0.01	0.03	0.06	0.03	0.03	0.03	0.03
Phosphorus, Total, mg/L	0.06	0.07	0.07	0.06	0.08	0.12	0.07	0.04	0.10
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.6	8.5	8.4	--	--	--	--	--	--
pH (lab), units	8.3	8.4	8.3	8.2	7.5	8.5	8.4	8.3	8.3
Specific Conductance, uS/cm	373	385	425	430	383	376	382	374	385
Total Alkalinity, mg/L $CaCO_3$	143	149	165	165	134	144	147	144	150
Chloride, mg/L	4	4	4	6	4	4	2	2	4
Mercury, ug/L	--	--	0.02	--	<0.02	<0.02	<0.02	<0.02	0.05
Colour, APHA units	5	5	7	--	4	4	4	4	6
Appearance	sl. turbid	sl. turbid	sl. turbid	sl. turbid	--	--	--	--	--

R - poor depletion in blank.
Q- result questionable

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-8	R-9	R-9	R-9	R-9	R-9	R-9	R-9	R-9
Station Location:	off LB	10m RB	.25RB	.50RB	.75RB	10m LB	10m RB	.25RB	.50RB
Date:	83/11/03	83/11/01	83/11/01	83/11/01	83/11/01	83/11/01	83/11/02	83/11/02	83/11/02
Time:	09:55	12:30	12:32	12:35	12:38	12:40	09:30	09:35	09:40
Total Coliforms, /100 mL	Q980	Q18400	4900	Q14500	Q1400	Q9000	Q25200	Q11700	Q9600
Fecal Coliforms, /100 mL	270	2900	1220	230	320	Q13000	4700	2100	2900
Fecal Streptococci, /100 mL	Q10	352	280	184	148	104	2200	352	176
Temperature, °C	--	4.0	4.0	4.0	4.0	9.0	--	--	--
Dissolved Oxygen, mg/L	12.3	12.3	12.8	12.4	12.7	10.4	11.2	13.5	12.2
% Oxygen Saturation	--	98	103	99	102	91	--	--	--
Biochemical Oxygen Demand, mg/L	R1.6	1.8	1.6	1.8	1.8	4.0	1.8	1.6	1.2
Dissolved Organic Carbon, mg/L	4	3	3	3	4	16	4	3	3
Total Suspended Solids, mg/L	9	5	5	5	13	11	9	4	9
Volatile Suspended Solids, mg/L	4	2	2	2	3	4	3	2	3
Nitrogen, Total Kjeldahl, mg/L	1.0	0.6	0.6	1.0	0.6	0.8	0.7	1.3	1.0
Nitrogen, Nitrate, mg/L	0.03	0.27	0.27	0.27	0.24	0.27	0.20	0.20	0.20
Nitrogen, Ammonia, mg/L	0.03	0.02	0.02	0.03	0.03	0.03	0.05	0.01	0.03
Phosphorus, Total, mg/L	0.05	0.07	0.06	0.13	0.06	0.09	0.08	0.07	0.07
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	--	8.6	8.6	8.6	8.6	8.5	8.6	8.5	8.6
pH (lab), units	8.4	8.4	8.4	8.4	8.4	8.2	8.3	8.3	8.3
Specific Conductance, uS/cm	400	369	370	374	370	385	390	387	384
Total Alkalinity, mg/L $CaCO_3$	156	143	143	143	145	155	143	142	143
Chloride, mg/L	4	6	4	4	6	30	6	6	2
Mercury, ug/L	<0.02	--	--	--	--	--	--	--	--
Colour, APHA units	5	5	4	5	5	78	5	5	5
Appearance	--	sl. turbid	sl. turbid	sl. turbid	sl. turbid	mod. turbid mod. brown mod. pulp odour	--	--	--

R - poor depletion in blank.
Q- result questionable.

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-9	R-9	R-10	R-10	R-10	R-10	R-10	R-10	R-10
Station Location:	.73RB	10m LB	.33RB	.33RB	.50LB	.33LB	10m LB	33RB	.50LB
Date:	83/11/02	83/11/02	83/11/01	83/11/01	83/11/01	83/11/01	83/11/01	83/11/02	83/11/02
Time:	09:45	09:52		Dup. #5	16:20	16:23	16:25	13:05	13:10
Total Coliforms, /100 mL	4100	Q169000	Q8400	E13600	Q13800	E51000	E49000	Q17100	Q11900
Fecal Coliforms, /100 mL	Q910	Q124000	2300	3500	Q9000	46000	Q170000	5400	Q9900
Fecal Streptococci, /100 mL	204	48	580	490	Q150	70	Q50	990	480
Temperature, °C	--	2.0	4.0	--	4.5	6.0	7.0	--	--
Dissolved Oxygen, mg/L	13.0	13.0	13.0	--	12.8	11.9	12.7	13.5	13.5
% Oxygen Saturation	--	99	10.4	--	104	100	109	--	--
Biochemical Oxygen Demand, mg/L	1.2	5.0	2.0	2.0	2.0	3.0	3.6	2.2	2.2
Dissolved Organic Carbon, mg/L	3	21	.2	2	3	10	11	4	4
Total Suspended Solids, mg/L	6	16	9	7	10	12	12	8	10
Volatile Suspended Solids, mg/L	3	9	3	3	3	4	4	4	4
Nitrogen, Total Kjeldahl, mg/L	0.9	1.0	0.7	0.7	0.6	0.7	0.7	1.7	0.6
Nitrogen, Nitrate, mg/L	0.17	0.17	0.30	0.30	0.27	0.27	0.24	0.20	0.14
Nitrogen, Ammonia, mg/L	0.03	0.05	0.07	0.05	0.05	0.08	0.03	0.03	0.03
Phosphorus, Total, mg/L	0.08	0.13	0.11	0.08	0.06	0.08	0.08	0.12	0.06
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0 01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.6	8.2	8.6	--	8.6	8.4	8.4	8.6	8.7
pH (lab), units	8.3	8.0	8.4	8.5	8.4	8.3	8.3	8.3	8.3
Specific Conductance, uS/cm	385	375	380	376	377	438	444	377	436
Total Alkalinity, mg/L $CaCO_3$	144	160	144	143	144	152	151	143	144
Chloride, mg/L	4	46	8	4	6	18	20	4	6
Mercury, ug/L	--	--	<0.02	--	Y.032	<0.02	--	<0.02	<0.02
Colour, APHA units	5	109	5	--	11	38	41	5	10
Appearance	--	--	sl. turbid	sl. turbid	mod. turbid lt. amber sl. pulp odour	mod. turbid lt. amber mod. pulp odour	mod. turbid lt. amber mod. pulp odour	--	--

Q-Result Questionable
E-Estimate
Y-Result Verified

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-10	R-10	R-10	R-10	R-10	R-10	R-10	R-11	R-11
Station Location:	.33LB	10m LB	.33RB	.33RB	.50LB	.33LB	10m LB	.75LB	.50LB
Date:	83/11/02	83/11/02	83/11/03	83/11/03	83/11/03	83/11/03	83/11/03	83/11/02	83/11/02
Time:	13:15	13:20		Dup. #9	09:55	10:00	10:05	14:05	14:10
Total Coliforms, /100 mL	68000	Q77000	E20400	Q8700	59000	80000	Q10400	Q12600	20000
Fecal Coliforms, /100 mL	Q190C	Q5400	Q9300	3500	Q18000	57000	Q70000	Q7100	Q9500
Fecal Streptococci, /100 mL	270	180	3200	2700	460	240	330	620	440
Temperature, °C	--	--	3.5	--	3.5	4.0	4.0	--	--
Dissolved Oxygen, mg/L	12.8	12.9	12.3	--	11.9	11.6	11.5	13.8	13.5
% Oxygen Saturation	--	--	97	--	94	93	92	--	--
Biochemical Oxygen Demand, mg/L	4.8	3.0	R1.8	R1.8	R2.0	R2.0	R2.0	2.0	2.0
Dissolved Organic Carbon, mg/L	9	10	3	4	4	9	9	5	6
Total Suspended Solids, mg/L	12	13	7	6	7	10	12	10	9
Volatile Suspended Solids, mg/L	5	5	3	3	3	4	5	5	4
Nitrogen, Total Kjeldahl, mg/L	1.0	1.0	1.0	0.8	0.7	1.1	0.9	0.7	0.9
Nitrogen, Nitrate, mg/L	0.17	0.17	0.14	0.14	0.14	0.14	0.14	0.20	0.20
Nitrogen, Ammonia, mg/L	0.03	0.05	0.06	0.05	0.03	0.03	0.10	0.05	0.05
Phosphorus, Total, mg/L	0.06	0.14	0.06	0.06	0.06	0.10	0.07	0.08	0.07
Phosphorus, ortho, mg/L	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.6	8.5	8.6	--	8.6	8.5	8.5	8.7	8.7
pH (lab), units	8.3	8.1	8.3	8.3	8.3	8.2	8.5	8.3	8.3
Specific Conductance, uS/cm	440	434	382	379	383	437	437	379	391
Total Alkalinity, mg/L $CaCO_3$	148	150	145	150	145	151	151	144	145
Chloride, mg/L	18	16	4	4	4	18	16	4	6
Mercury, ug/L	0.02	0.02	0.02	--	<0.02	<0.02	--	--	--
Colour, APHA units	30	36	5	--	8	35	36	7	12
Appearance	--	--	sl. turbid	sl. turbid	sl. turbid sl. pulp odour	mod. turbid lt. brown	mod. turbid mod. brown mod. pulp odour	--	--

R - poor depletion in blank.

APPENDIX 7

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DETAILED WATER QUALITY
OCTOBER AND NOVEMBER 1983 SURVEYS

Transect:	R-11	R-11	R-12	R-12	R-13
Station Location:	.25LB	10m LB	off RB	off RB	off RB
Date:	83/11/02	83/11/02	83/11/01	83/11/02	83/11/01
Time:	14:15	14:20	12:00	15:50	15:45
Total Coliforms, /100 mL	33000	39000	Q183000	Q11300	Q179000
Fecal Coliforms, /100 mL	27000	24000	Q76000	5400	Q25200
Fecal Streptococci, /100 mL	450	280	310	350	Q80
Temperature, °C	--	--	--	3.5	--
Dissolved Oxygen, mg/L	13.2	13.4	12.5	14.5	12.4
% Oxygen Saturation	--	--	--	114	--
	2.8	5.0	2.0	2.4	2.6
Biochemical Oxygen Demand, mg/L	2.8	5.0	2.0	2.4	2.6
Dissolved Organic Carbon, mg/L	8	9	5	4	5
Total Suspended Solids, mg/L	12	10	7	19	14
Volatile Suspended Solids, mg/L	5	5	2	6	5
Nitrogen, Total Kjeldahl, mg/L	0.7	1.0	0.6	0.9	1.0
Nitrogen, Nitrate, mg/L	0.17	0.20	0.34	0.20	0.27
Nitrogen, Ammonia, mg/L	0.05	0.01	0.03	0.05	0.05
Phosphorus, Total, mg/L	0.08	0.08	0.08	0.09	0.15
Phosphorus, ortho, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
pH (field), units	8.7	8.7	8.6	8.6	8.4
pH (lab), units	8.2	7.9	8.4	8.4	8.3
Specific Conductance, uS/cm	4.5	427	397	396	410
Total Alkalinity, mg/L $CaCO_3$	148	151	146	146	148
Chloride, mg/L	12	4	8	6	10
Mercury, ug/L	--	--	<0.02	0.08	--
Colour, APHA units	24	28	9	11	13
Appearance	--	--	--	sl. turbid lt. amber mod. pulp odour	--

Q-Result Questionable

APPENDIX 8

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA
DIURNAL DISSOLVED OXYGEN, TEMPERATURE
AND PER CENT SATURATION DATA
FROM DIURNAL MONITORING AT
CECIL FERRY CROSSING IN OCTOBER
AND NOVEMBER, 1983

APPENDIX 8: DIURNAL DISSOLVED OXYGEN, TEMPERATURE, AND PER CENT SATURATION DATA DIURNAL MONITORING AT CECIL FERRY CROSSING (TRANSECT R10) ON THE NORTH SASKATCHEWAN RIVER, OCTOBER AND NOVEMBER, 1983 SURVEYS

Location	Monitoring Period	Time	D.O. mg/L	Temperature °C	Saturation %
South Shore	1600 October 17 to 0200 October 18, 1983	1600	14.6	3.8	116
		1700	15.0	3.8	119
		1800	14.9	3.8	119
		1900	14.5	3.8	115
		2000	14.2	3.8	113
		2100	13.8	3.9	110
		2200	13.6	3.8	108
		2300	13.4	3.7	107
		2400	13.2	3.6	104
		0100	13.2	3.3	103
		0200	13.2	3.1	103
North Shore	1800 October 18 to 1400 October 19, 1983	1800	12.7	4.7	100
		1900	12.4	4.7	98
		2000	12.2	4.5	96
		2100	12.0	4.3	949
		2200	11.9	4.1	94
		2300	11.7	4.0	92
		2400	12.0	3.9	94
		0100	11.7	3.8	91
		0200	11.9	3.7	92
		0300	11.6	3.7	92
		0400	11.7	3.6	91
		0500	11.7	3.6	91
		0600	11.6	3.4	90
		0700	11.6	3.3	91
		0800	11.4	3.2	91
		0900	11.6	3.2	90
		1000	11.4	3.5	91
		1100	11.7	3.8	92
		1200	11.9	4.2	94
		1300	12.2	4.8	96
		1400	12.4	5.1	98

APPENDIX 8: DIURNAL DISSOLVED OXYGEN, TEMPERATURE, AND PER CENT SATURATION DATA DIURNAL MONITORING AT CECIL FERRY CROSSING (TRANSECT R10) ON THE NORTH SASKATCHEWAN RIVER, OCTOBER AND NOVEMBER, 1983 SURVEYS

Location	Monitoring Period	Time	D.O. mg/L	Temperature °C	Saturation %
South Shore	1600 October 31 to 1500 November 1, 1983	1600	11.9	4.1	94
		1700	12.4	3.9	98
		1800	11.9	3.9	94
		1900	11.8	4.0	94
		2000	11.9	4.0	94
		2100	11.6	3.9	92
		2200	11.5	3.8	91
		2300	11.4	3.7	90
		2400	11.2	3.7	89
		0100	11.0	3.7	87
		0200	11.1	3.7	88
		0300	11.0	3.6	87
		0400	11.0	3.5	87
		0500	11.0	3.5	87
		0600	11.0	3.5	87
		0700	11.1	3.5	88
		0800	11.2	3.5	89
		0900	11.0	3.5	87
		1000	11.2	3.5	89
		1100	11.4	3.6	90
		1200	11.7	3.7	93
		1300	11.8	3.9	94
		1400	12.0	4.0	95
		1500	12.2	4.1	97
North Shore	1700 November 1 to 1700 November 2, 1983	1700	12.0	4.7	97
		1800	11.9	4.5	97
		1900	11.8	4.3	96
		2000	11.7	4.2	95
		2100	11.7	4.1	95
		2200	11.6	4.0	93
		2300	11.7	3.9	93
		2400	11.6	3.7	93
		0100	11.5	3.6	92
		0200	11.5	3.5	92
		0300	11.4	3.4	91
		0400	11.3	3.3	90
		0500	11.3	3.2	90
		0600	11.3	3.0	90
		0700	11.3	2.9	90
		0800	11.2	2.8	87
		0900	11.3	2.5	88
		1000	11.4	2.6	89
		1100	11.5	2.6	90
		1200	11.5	2.5	90
		1300	11.7	2.7	90
		1400	11.9	2.8	91

APPENDIX 9

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA - HEAVY METALS AND TRACE SUBSTANCES AT SELECTED SITES - OCTOBER AND NOVEMBER 1983 SURVEYS

APPENDIX 9: NORTH SASKATCHEWAN RIVER

PRINCE ALBERT AREA SELECTED SITES
HEAVY METALS, TRACE SUBSTANCES
OCTOBER AND NOVEMBER, 1983 SURVEYS

DATE	Above P.A. STP R5 - Mid River (.5 RB)		Cole Rapids R12 - Off Right Bank	
	831018	831101	831018	831101
Time	08:55	10:15	11:20	12:00
Aluminum, mg/L	0.2	0.34	0.15	0.19
Arsenic, mg/L	0.001	0.0007	0.001	0.0005
Barium, mg/L	0.062	0.061	0.059	0.066
Beryllium, mg/L	<0.001	<0.001	< 0.001	< 0.001
Boron, mg/L	0.03	0.03	0.03	0.03
Cadmium, mg/L	<0.001	<0.001	< 0.001	< 0.001
Chromium, mg/L	0.004	0.003	0.006	0.005
Cobalt, mg/L	<0.001	<0.001	< 0.001	< 0.001
Copper, mg/L	0.006	<0.001	0.004	0.001
Cyanide, mg/L	<0.0001	0.0005	0.0004	0.0011
Iron, mg/L	0.22	0.30	0.17	0.19
Lead, mg/L	0.007	<0.005	< 0.005	< 0.005
Manganese, mg/L	0.019	0.014	0.02	0.015
Mercury, mg/L	<0.00002	<0.00002	< 0.00002	< 0.00002
Molybdenum, mg/L	0.01	<0.005	0.01	< 0.005
Nickel, mg/L	<0.001	0.001	< 0.001	< 0.001
Selenium, mg/L	<0.001	<0.001	< 0.001	< 0.001
Silicon, mg/L	0.13	<0.005	0.09	0.2
Silver, mg/L	<0.001	<0.001	< 0.001	< 0.001
Titanium, mg/L	0.002	0.005	< 0.001	< 0.001
Vanadium, mg/L	0.01	<0.01	0.01	< 0.01
Wolfram, mg/L	<0.005	<0.005	< 0.005	< 0.005
Zinc, mg/L	0.003	0.011	0.004	0.005
Calcium, mg/L	>50	44	>50	47
Magnesium, mg/L	15	16	15	17
Potassium, mg/L	1.8	1.4	1.8	1.6
Sodium, mg/L	14	13	15	17
Phosphorus, mg/L	0.2	0.1	0.2	0.1

APPENDIX 10

NORTH SASKATCHEWAN RIVER - PRINCE ALBERT AREA- TOTAL MERCURY RESULTS AT SELECTED SITES- OCTOBER AND NOVEMBER 1983 SURVEYS

APPENDIX 10: TOTAL MERCURY CONCENTRATIONS (mg/l) in Water Samples From Selected Sites on the North Saskatchewan River in October and November 1983 Surveys

TRANSECT	SAMPLING DATES	STATION LOCATION								
		OFF LB	10m RB	.25 RB	.33 RB	.5 RB	.33 LB	.75 RB	10m LB	OFF LB
R5	83/10/17	--	--	<00002	--	.00002	--	.00002	--	--
	83/10/18	--	--	≤00002	--	≤00002	--	<.00002	--	--
	83/10/19	--	--	≤00002	--	.00002	--	.00003	--	--
	83/10/31	--	--	≤00002	--	≤00002	--	.00003	--	--
	83/11/01	--	--	.00004	--	≤00002	--	<00002	--	--
	83/11/02	--	--	.00018	--	.00007	--	.00005	--	--
R8	83/10/18	--	<00002	<.00002	--	.00002	--	--	--	.00002
	83/10/19	--	.00002	.00002	--	.00002	--	--	--	.00003
	83/10/20	--	.00005	--	--	.00010	--	.00004	--	.00004
	83/11/01	--	.00003	<.00002	--	<.00002	--	--	--	.00004
	83/11/02	--	.00005	<.00002	--	.00004	--	--	--	.00002
	83/11/03	--	<.00002	<.00002	--	<.00002	--	<.00002	--	.00005 (<.00002)
R10	83/11/18	--	--	--	≤00002	.00002	<.00002	--	--	--
	93/11/19	--	--	--	≤00002	<.00002	<.00002	--	--	--
	83/11/20	--	--	--	≤00002	<.00002	<.00002	--	--	--
	83/11/01	--	--	--	≤00002	.00032	<.00002	--	--	--
	83/11/02	--	--	--	≤00002	<.00002	.00002	--	.00002	--
	83/11/03	--	--	--	.00002	<.00002	<.00002	--	--	--
R12	83/10/18	<.00002	--	--	<0.02	.00002	--	--	--	--
	83/10/19	.00002	--	--	--	--	--	--	--	--
	83/11/01	<.00002	--	--	--	--	--	--	--	--
	83/11/02	.00002	--	--	--	--	--	--	--	--